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DROUGHT AND FAMINE RELATIONSHIPS IN SUDAN: POLICY IMPLICATIONS

Tesfaye Teklu
Joachim von Braun
Elsayed Zaki

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FOREWORD

Sudan experienced severe food shortages and famines during the 1970s and 1980s. For a country known for its vast agricultural resources, this is both unfortunate and ironic. This research report explores the basic factors that contributed to the recurrence of this phenomenon and identifies policies and actions for avoiding famines and achieving sound and sustainable food policies.

The study demonstrates the complexity of policy for famine prevention, which encompasses macroeconomic reform, promotion of agricultural production and technological change, market development, employment promotion, and interventions for health and nutrition. The researchers extensively investigated all these aspects from primary field data gathered before and after the 1984-85 famine as well as from secondary data. The analysis clearly indicates that famines in Sudan are more often than not a result of long-term policy failures, and in environments of political unrest and weak infrastructure, droughts serve as a trigger to famine.

Famines appear as short-term crises, but this study and a parallel one by IFPRI in Ethiopia show that they arise out of long-term developments in policy, economic strategy, and ecology. This calls for research, such as this study, on these long-term factors, not just research into the short-term aspects of crises.

The persistence of famine in Sudan in the 1990s shows that such long-term research has application to current situations and could be of great assistance to Sudan and to other countries in Sub-Saharan Africa with similar conditions. IFPRI hopes that policymakers will regard the research findings and the recommendations as valuable contributions to their endeavors to reduce and ultimately eliminate incidences of famine.

Just Faaland

Director General
October 1991

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Tesfaye Teklu
Joachim von Braun
Elsayed Zaki

1

SUMMARY

Famine has persisted in Sudan through the 1980s and into the 1990s. Drought is one of its immediate causes and must be understood in a broad context if famine vulnerability is to be reduced with appropriate policy. This study asks, What are the determinants of famine in Sudan? What role does drought play? Who is affected? And further, What has the experience been with private action, including market and household responses, and with public action, including policies and programs to deal with the problem? Quantitative analyses in the study are based on household-level data specifically collected for this research in western Sudan, available data from other sources, and market- and sector-level information.

Periods of drought have occurred throughout the history of Sudan. In most cases these have been followed by famine and outbreaks of disease. The 1984-85 famine was the outcome of a long process of drought and desertification, absent or misplaced public food and agricultural policy, and insufficient public response. Lacking in the government's response were a permanent institution responsible for famine preparedness and the political will to intervene early to prevent large-scale hunger and mass movements. Emergency food aid, which largely followed official recognition of the existence of famine, was constrained by untimely availability and logistical and managerial limitations. In addition, the macroeconomic policy environment in the 1970s and 1980s was not conducive to preventing erosion of the country's capacity to deal with the drought crises. War and civil unrest further undermined such capacity.

A large drop in agricultural production occurred in 1984/85. This decline translated into a large drop in farm employment. A strong link between agricultural production and income (from crop production, local off-farm wage employment, and livestock) increased the extent of income failure. As shown by an IFPRI survey in the famine-prone area of Kordofan in western Sudan, a large drop in nominal income, coupled with a rapid rise in food prices, resulted in a severe and widespread decline in purchasing power. Farmers had to dispose of their animals to maintain their food entitlement and to avoid imminent loss through death of the animals. Asset-poor households had to depend greatly on nonagricultural products and transfers to augment their low income. Some farmers had to move out from their villages much earlier than the normal season in search of work or relief support. Given the large share of income spent on food, households had to adjust their food consumption by cutting the size and frequency of meals and by changing the composition of their diet.

The original survey information from western Sudan shows that farmers adopt multiple coping paths and responses that involve substitutions in production, income, assets, and consumption. Households vary in their emphasis on the choice of coping responses. In general, they try to avoid action that would endanger their future survival. Their success in coping, however, is unequal across households

because of unequal income and asset bases and unequal access to community risk-sharing networks and public support. Famine strikes different socioeconomic groups in different ways. The evidence of 1984-85 shows that although the famine had a distinct location character, some groups were affected much more than others. Hardest hit were camel nomads in the northern arid zones, especially small-herd owners; asset-poor households, particularly recent settlers and capital-constrained female-headed households; and families without working members. The problem of recent settlers posed a special dilemma in light of the presence of a large number of war refugees in the area. In general, the burden of coping fell heavily on low-income households with a very small protective income source or asset base. The evidence also shows a rapid shift in the phases of and participation in the coping process that was adopted by the rural population in western Sudan, a severely affected famine area.

The study traces the effects of drought on production, markets, consumption, and nutrition, focusing on the 1984-85 famine, its origin and aftermaths. Related findings are briefly reviewed below. Rainfall levels have declined in Sudan during the past three decades: mean annual rainfall declined by 6.7 percent between 1960-69 and 1970-79 and by 17.7 percent between 1970-79 and 1980-86. Furthermore, year-to-year fluctuations in rainfall around a trend line seem to have increased, especially in arid and semi-arid zones. For example, coefficients of variation increased, on average, from 16 percent in the 1960s to 21 percent in the 1970s and 32 percent in the 1980s in western Sudan.

The decline in rainfall levels has resulted in low growth in cereal production, largely because of short-run effects on yield, as evident from a comparison of growth estimates with and without the drought year of 1984. Cereal production is also marked by considerable and increasing year-to-year fluctuation. Yield variability has been strongly associated with variability of rainfed crops.

Drought-production relationships show that a 10 percent drop in annual rainfall from mean levels implies a 5.0 percent drop in cereal production and a 3.7 percent drop in yield at the country level. Sorghum yield and, consequently, production are shown to be more affected than millet by declines in rainfall. A 10 percent drop in annual rainfall results in drops of 7.3 and 3.0 percent in sorghum and millet production, respectively.

Markets for cereals are thin and very responsive to production changes. Deflated (real) cereal prices increased more than three times in the main famine year of 1984-85 compared with 1982-83. The related time-series analysis in the study shows that, under the prevailing trade and market-structure conditions, a 10 percent drop in production led to an approximate 26 percent increase in real prices of cereals in the same year. A 10 percent reduction in stocks (calculated at mean values) increased prices by 8 percent. Trade and aid contributed little toward mitigating the price effects of the drought-driven production fluctuation.

The terms-of-trade change in disfavor of livestock and cash crops signals one element of the decline in the purchasing power of rural households. The terms of trade between domestic cereal and livestock changed drastically as a consequence of the drought in the 1980s. They increased from 1:1 in 1980 to about 1:8 or 1:10 in 1984-85. Thus, to acquire the same amount of cereals, 8 to 10 times more livestock had to be offered in 1984-85 than in 1980. The model analysis shows that a 10 percent drop in cereal production resulted in an 18 percent increase in the cereal and livestock terms of trade. Domestic terms of trade between cereals and cash crops, such as groundnuts and sesame, increased by 2 to 3 times as a consequence of the drought-related declines in cereal production. These combined production and price effects resulted in food-entitlement failure for large segments of the rural population.

Although considerable relative differences prevailed between regions, the general food price movement during the food crisis in 1984-85 spread all over the country, thereby spreading the burden of the crisis to the poor in nondrought and urban areas. A statistical model testing for market integration shows that food markets were not segmented and that there was strong transmission of prices. Though interregional commodity flows were hampered by high market-transaction costs, particularly transport costs, a situation of "market failure" during the food crisis was not observed. However, the dramatic changes in the domestic terms of trade could happen only because of the limited integration of the country into the international exchange economy. A less constrained administrative and foreign exchange situation, or more (timely) food aid, might have prevented some of the large movements in prices.

The growth of aggregate per capita food availability was negative in the 1970s and 1980s, largely because of low growth in production relative to population growth. In 1984, there was a particularly large drop in per capita food availability despite measures to mitigate consumption shortfalls, such as increased food aid, imports, and off-take from public grain reserves. The drop varied by region and the impact by type of household. Adjustment pressures to drought-induced price and income changes are much greater for the low-income households, particularly for those in drought-prone areas. This applies also to child nutritional welfare in these households.

The combined production and price effects translated into nutritional deterioration. Deficiencies in rural health services also played a key role in this context. As the recurrent drought had stripped many rural households of their asset base in the early 1980s, the main drought in 1984 immediately translated into a drastic nutrition problem. Many families were left with no ability to cope. Thus the observed parallel movement of prices and malnutrition on a month-by-month basis suggests that price information can be of only limited value as an indicator of "early" warning when the asset base is already deteriorated. It also calls attention to the need to prevent extreme price instability in the interest of child nutritional welfare.

Assessment of child nutritional status in the postfamine period of 1986-87, based on a large sample survey, shows a sizable presence of child undernutrition, with significant variations across regions, locations, and seasons. Child characteristics (such as sex and age), frequency and type of food intake, human capital endowment (that is, mother's education), health and sanitation environment, and incidence of disease are found to be important determinants of child malnutrition status. In addition, it is confirmed that cereal price increases not only significantly reduce household staple food consumption but also contribute to children's nutritional deterioration (weight-for-age). The combination of lack of food at the household level and acute diarrhea in children results in life-threatening nutritional deterioration of large proportions of preschool children. This analysis, stressing policy action for nutritional improvement, requires that food availability, employment, and community health and sanitation be addressed simultaneously.

The 1984-85 crisis uprooted large segments of the rural population and resulted in depletion of their assets and in stress migration into urban areas. Future food price explosions (in the context of another drought) will hit these people even more as wage earners without degrees of freedom to cope.

The evidence of the 1984-85 famine confirms that drought is a major determining factor in famine in Sudan. Decline in the level of rainfall and its increased variability substantially undercut the food entitlement of large segments of the population through production and employment effects. The risk increased during the 1980s because of continued low and variable production, slow recovery in the asset base, permanent out-migration, and increased dependency on volatile rural markets. In fact, the new dynamics of famine make it much more difficult to identify and trace vulnerable groups on a continuous basis for policy targeting.

The microhousehold and community-level effects of specific projects and programs aimed at reducing famine are reviewed on the basis of original survey information. This includes an assessment of food aid and relief management in Kordofan, asset-rebuilding programs (including both food for tree-planting and livestock restocking), and agricultural-technology dissemination (in Darfur). In conclusion, from these project experiences, the critical role of sustainable food production in the rainfed sector of Sudan is emphasized. The key components of such a strategy include improvement of resource conservation and management, development and dissemination of labor-augmenting technology, and promotion of human and physical infrastructure as well as institutional capacity. Relief and rehabilitation are necessary integrants of the whole development process.

Based on a review of past policies and problems, the study emphasizes a set of general policy priorities for famine prevention that includes political stability, that is, an end to wars; participation of the rural population, especially through decentralization, in relief and rehabilitation; macroeconomic policy reforms, especially of exchange rate and pricing policies, and the control of inflation.

The specific policy priorities for famine prevention derived from the quantitative analysis include (1) promotion of sustainable growth in the traditional rainfed agriculture through expansion of rural infrastructure; provision of labor-intensive public works programs; input supply, with scope for private-sector involvement; adaptive research, technology, and extension; and protection of the environment; and (2) emergency preparedness and relief with buffer stocks for price stabilization, improved relief management and early warning systems, strengthening of rural health and sanitation, and comprehensive legislation for famine prevention.

2

FAMINE DEBATE, CONCEPTUAL FRAMEWORK, AND STUDY APPROACH

The Research Questions

Sudan has been hit hard by the droughts in the 1970s and 1980s. Loss of the resource base of households, especially in the west and northeast, has led to serious economic deprivation. The 1984-85 famine is a recent case in point. This study acknowledges the important and disturbing role of the long-lasting armed conflict in southern Sudan in undermining the economic and institutional base of the country and thereby increasing overall famine vulnerability. The regional focus of the study is, however, on the western and northern provinces of the country.

Understanding these problems requires a properly conceived framework to examine the factors contributing to the process of recurring severe food shortages and entitlement failures. A brief overview of the ongoing debate on the causes of the 1984-85 famine is juxtaposed here with a conceptual framework. Past policy failures have created the environment that now makes drought a central cause of famine crises and persistent hunger in large parts of Sudan. This point will be discussed in Chapter 7 within an overview of the "disenabling" economic policy environment in Sudan during the past three decades.

While focusing on drought, the study begins with the hypothesis that famine in Sudan is the result of interactions of various determinants. Drought is one of these, but to stimulate an appropriate policy response that will reduce the famine vulnerability of the people, it must be understood in a broad context. The research questions of this study are, What are the determinants of famine in Sudan? What role does drought play? Who is affected? And what has been the experience with private coping responses, including market and household reactions, and with public action, including policies and programs for dealing with the famine problem?

The Debate on Causes of the 1984-85 Famine

Studies on the 1984-85 famine in Sudan converge on two key facets. First, famine is an outcome of a long process. The main contributing components are drought and desertification (Ibrahim 1984; Ibrahim 1985; ILO 1985; IES 1986), lack of or misguided government food and agricultural policies (Abdel Ati 1988), and absence of institutional capacity and political will to respond effectively to famine and economic crises (Shepherd 1988). Second, the outcome of such a process is often articulated in declining regional (but not necessarily national) food availability, which, because of extreme infrastructural deficiencies, results in mass starvation and excess deaths due to hunger and diseases.

A large-scale decline in food availability is considered central to an explanation of widespread food shortages and starvation in Sudan, but not in general as a cause of famine (Drèze and Sen 1990). By 1981/82 the cereal food balance in Darfur had dropped by 23 percent from its 1971/72 level, and in 1983 there was a deficit of 76 percent of the sorghum requirements in Kordofan (ILO 1985). El-Sammani points out that in 1984 the food gap was 80 percent of the total cereal requirement in Kordofan (IES 1986). In the case of pastoralists, who depend mainly on livestock, the effects of famine were often transmitted through loss of livestock and deterioration of terms of trade (ILO 1985).

Desertification (loss of productive land) is itself an outcome of natural and human actions. The desertification process has intensified since the beginning of the dry cycle of 1968 because of a declining pattern of precipitation, a southward shift of the rainfall belt, increased variability of rainfall, and enhanced human activities such as overcultivation, overgrazing, woodcutting, and deforestation. The process was exacerbated in the early 1980s by the occurrence of consecutive droughts that caused the deterioration of rangelands and a large drop in land productivity. The great famine of 1984-85, according to those who ascribe famine to ecological imbalance, was the outcome of a long process of desertification intensified by years of droughts.

The famine of 1984-85 has also been ascribed to faulty agricultural policy. Central to this argument is that the pursuit of "modernization" of the agricultural sector, which often meant the promotion of large-scale, capital-intensive technology in high-potential areas, has contributed to the neglect of the smallholder traditional crop and livestock sectors and a deterioration of the ecological balance. The neglect of traditional smallholders, which is marked by low levels of their food production and income base, means a low level of preparedness on the part of the farm population to survive consecutive seasons of crop failures. In the case of the 1984-85 famine, because of low and variable income, farmers were ill-prepared in terms of generating or accessing their staple foods, especially in the western regions of Darfur and Kordofan and in Eastern Region.

The government's ineffective response to protecting these rural populations in 1984-85 was also considered a contributing factor to the resulting large-scale starvation and deaths (Shepherd 1988). Lack of a permanent institution responsible for famine preparedness and response, absence of a famine policy, failure to invoke the famine codes of 1920, slow official recognition of the risky situation, and late intervention were characteristics of the situation in 1984-85. There were limited and ad hoc responses, but they were not sufficient to avert or minimize the crisis.

The writings on Sudan point out that even though the famine of 1984-85 was nationwide, it was more concentrated in the arid and semi-arid areas of the western and eastern regions. These areas are characterized by ongoing desertification intensified by consecutive droughts, highly variable seasonal food production, an undeveloped infrastructure base, and neglect on the part of the government in enhancing and shielding the income capacity of the population. In addition, these regions have been identified as the areas of highest population increase (after Khartoum and Upper Nile) in the 1973-83 period (ILO 1985).

The causes of famine suggested by these writers largely fit into the profile of African countries that fail to enhance and protect the income-generating capacity of their most vulnerable population in times of crisis (Drèze 1989). The search for an in-depth understanding of these causes is the primary component of the present study. This pursuit is undertaken in a framework that makes the entitlement approach (Sen 1981) central to understanding the causes of and ability to cope with crises. However, great importance is also attached to the food production and supply dimensions as key variables in explaining the relationships between the production-employment-income-consumption components in the African context (Mellor and Gavian 1987), particularly in Sudan. As will be shown, food production and food entitlement failures are very closely linked in Sudan. It will be argued that strengthening food entitlements has to be brought about to a large extent—but not only—by expanding agricultural growth in the Sudan through employment generation and increased food supply.

Conceptual Framework

A clear distinction needs to be made between hunger (including seasonal hunger), undernutrition, and famine.

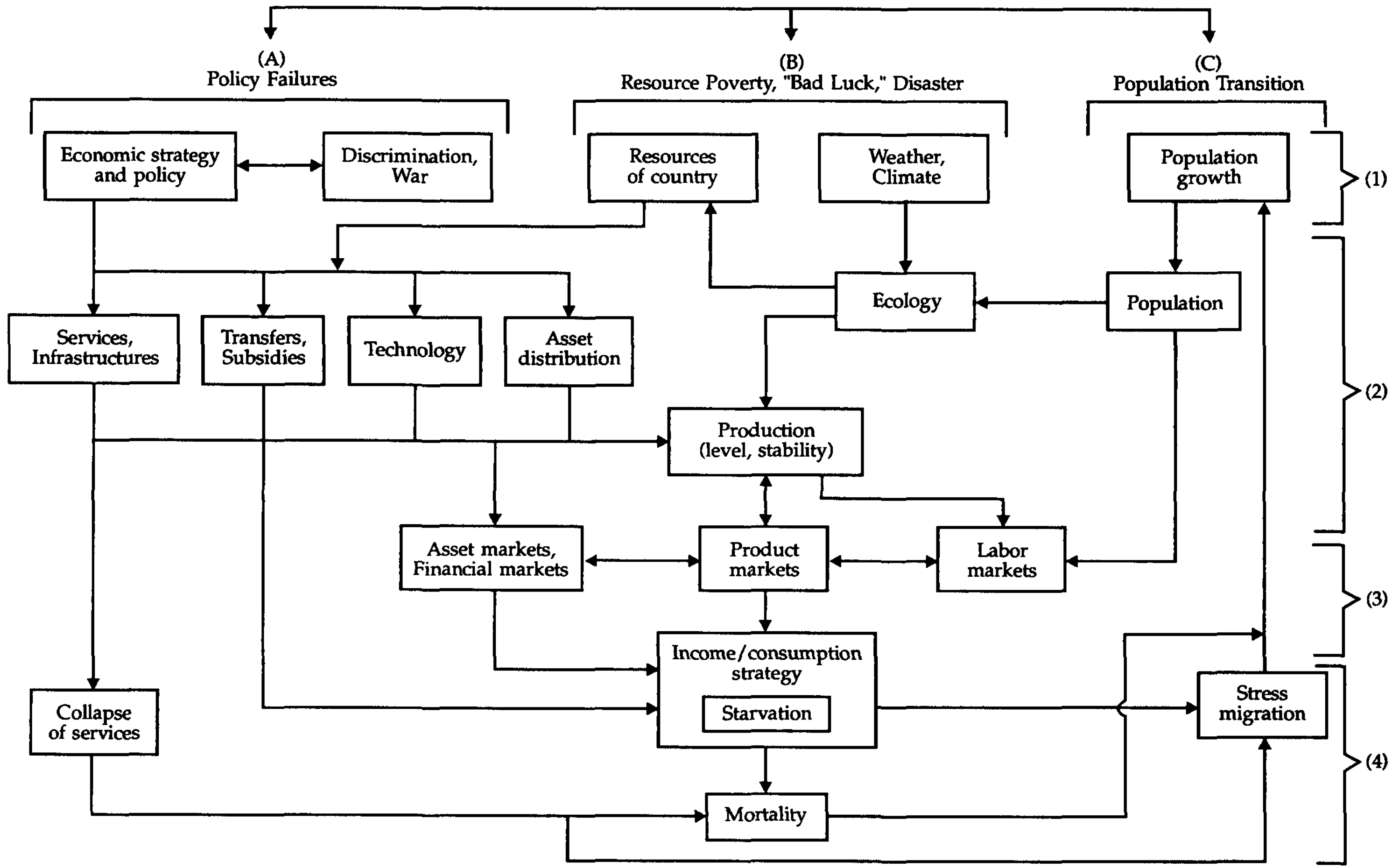
Hunger—largely an advocacy rather than a scientific term—is defined here as not having enough to eat to lead a healthy and active life. It is a recurring feature of the absolute poor, especially in developing countries. In connection with the above, seasonal hunger is often associated with the population in rural areas, where it occurs during the preharvest season when food stocks of the rural poor are depleted and the affected population can ill afford to purchase food because of related higher seasonal prices.

Undernutrition is due to a deficient intake of specific nutrients in a diet. It can lead to illness (lack of energy, retardation, or blindness, for instance) or even death, although the symptoms may not be recognized as indications of nutrient deficiencies. Interactions between undernutrition and illness are particularly complex.

Famine is the presence in a specific area or country of widespread and extreme hunger that results in drastic loss of body weight and a rising death rate. The causes may be shortages in food availability or inaccessibility of available food due to drought, flood, political (war) or economic disruptions, or massive income declines brought about by factor or product market disruptions. Most frequently, famines are a result of complex combinations of some of these causes. Famines are mainly a rural feature and occur in areas where chronic undernutrition is often observed.

A root cause of famine is poverty, including the associated vulnerability to disaster. Yet poverty may be seen as an endogenous outcome of resources and policies. Figure 1 is an attempt to delineate relationships between root causes and symptoms of famine events in a rough sketch. Endogenous and exogenous relationships are conceptualized at different levels of analysis. The broad interactions between policy failures; resource poverty, "bad luck," and disaster; and the population transition process are depicted. Cause-and-effect relationships are then distinguished with some of the more important nonexhaustive indications of feedback mechanisms between the four levels of analysis: (1) the top layer comprises the level of economic strategy and policy interacting with discrimination, social conflicts, and wars; resource endowments of the country and their relationship to climate or disaster events influencing levels of poverty and instability of the (food) system; and population growth. Little comprehensive research exists in Africa on

Figure 1—Determinants of and relationships in famines



Note: (A), (B), and (C) are interrelated clusters of causes; (1), (2), (3), and (4) are levels of analysis.

the interactions between these three basic clusters in constituting famine events—for instance, the political economy of hunger and endogenous population growth; (2) the second layer contains policy interventions (such as subsidies, distributional policies, and the investment portfolio) that influence the input/output relationships (production levels and stability); (3) policy interventions interact with the price formation and interlinkages in capital, labor, and output markets depicted in the third layer; and (4) the last layer of assessment of famine consequences relates to the actual observation of income and consumption failures and the resulting starvation and excess mortality interacting with the collapse of services and stress migration.

Famine outcomes are an indication of a failure of the coping process that is observed at household and individual levels. Figure 2 provides a simplified anatomy of a household economy linked to outcomes determined at layers (1), (2), and (3) in Figure 1. In addition, it shows a pattern of responses at the household level and sources of variation in household capacity to respond to crisis.

Figure 2 represents a typical case of a sedentary farm household. A great proportion of its resources, land and labor in particular, goes into crop production. In addition, part of the family labor is switched to generate income from other sources to supplement crop income. Household income at any particular point in time is a combined outcome of these income sources. Exogenous changes in climate, market prices, and public policies (outcomes in Figure 1) influence the level as well as the sources of household income. Income generated from these sources is translated into consumption and asset accumulation. Food consumption is presumed to affect household nutritional status, which in turn influences the incidence of morbidity and mortality in interaction with the sanitary and health environment. Part of the income that is saved is often invested in livestock to ensure continuity as well as protection of future income flow.

Various paths of adjustments open to the household are displayed in Figure 2: production, labor (migration), asset, transfer (individual, community, or public), and consumption paths. A large drop in crop production is likely to subject a household to severe stress because of strong production-income-consumption links. However, a production shortfall should not necessarily be translated into much-reduced food intake if other paths of adjustment prevent income and consumption failures. Of course, the relative importance of these paths shifts, depending on the source, persistence, and phase of the process that has triggered the food distress.

The simple structure in Figure 2 does not capture variations in a household's demographic life cycle and entitlement endowment (level of skill and experience, access to resources, accumulation of assets, and access to steady outside-income sources). These differences contribute variation in the choice of responses and success of coping. Households with low income, particularly those that are mainly exposed to high-risk income and have few income and asset sources, are at high risk. The burden of coping falls on these households unless community or public support reinforces their coping devices.

Overview of the Study Approach

The middle path in Figure 1 especially traces the drought-famine link pursued in this report. In Figure 3, this key path is isolated, and the types of interventions

Figure 2—Paths of household response to declining food entitlement

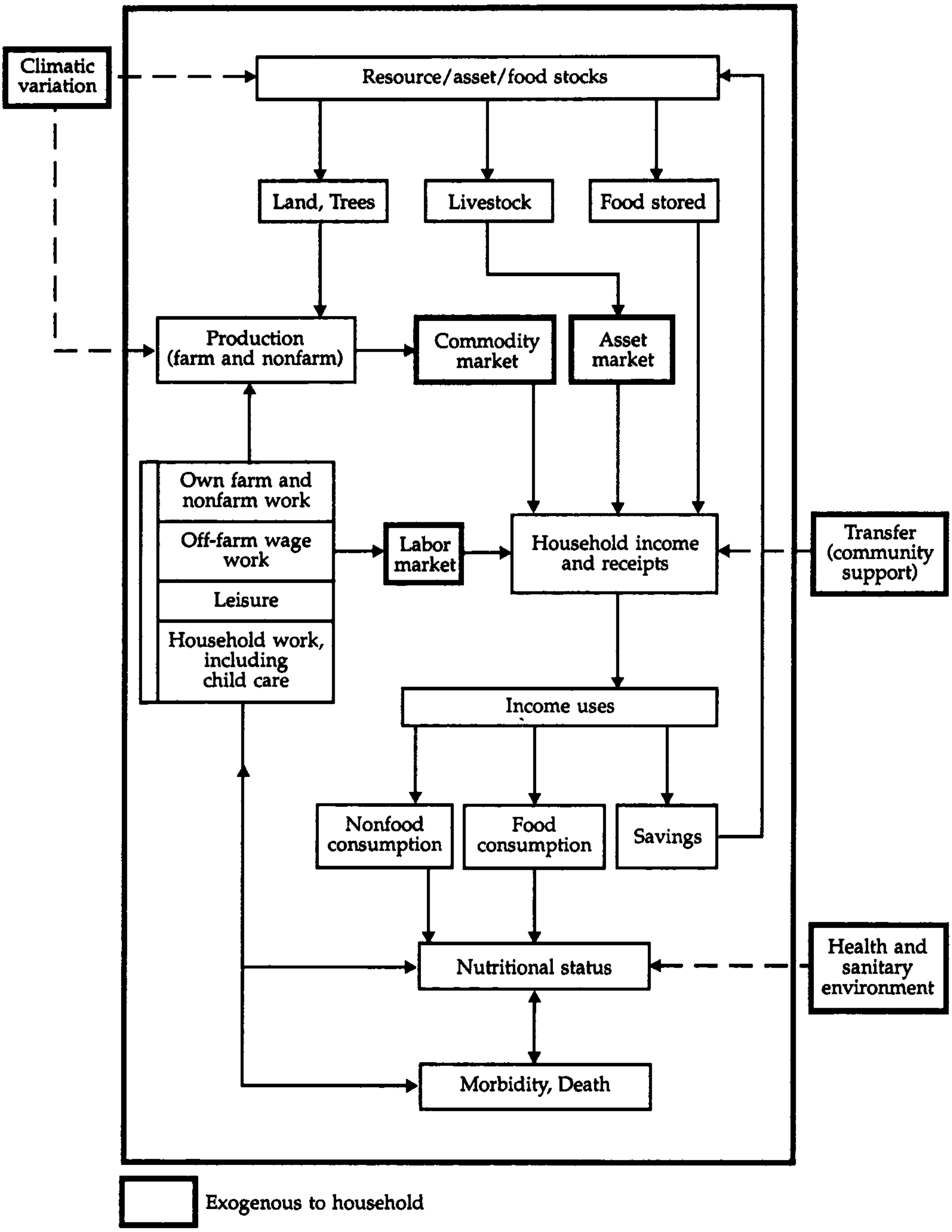
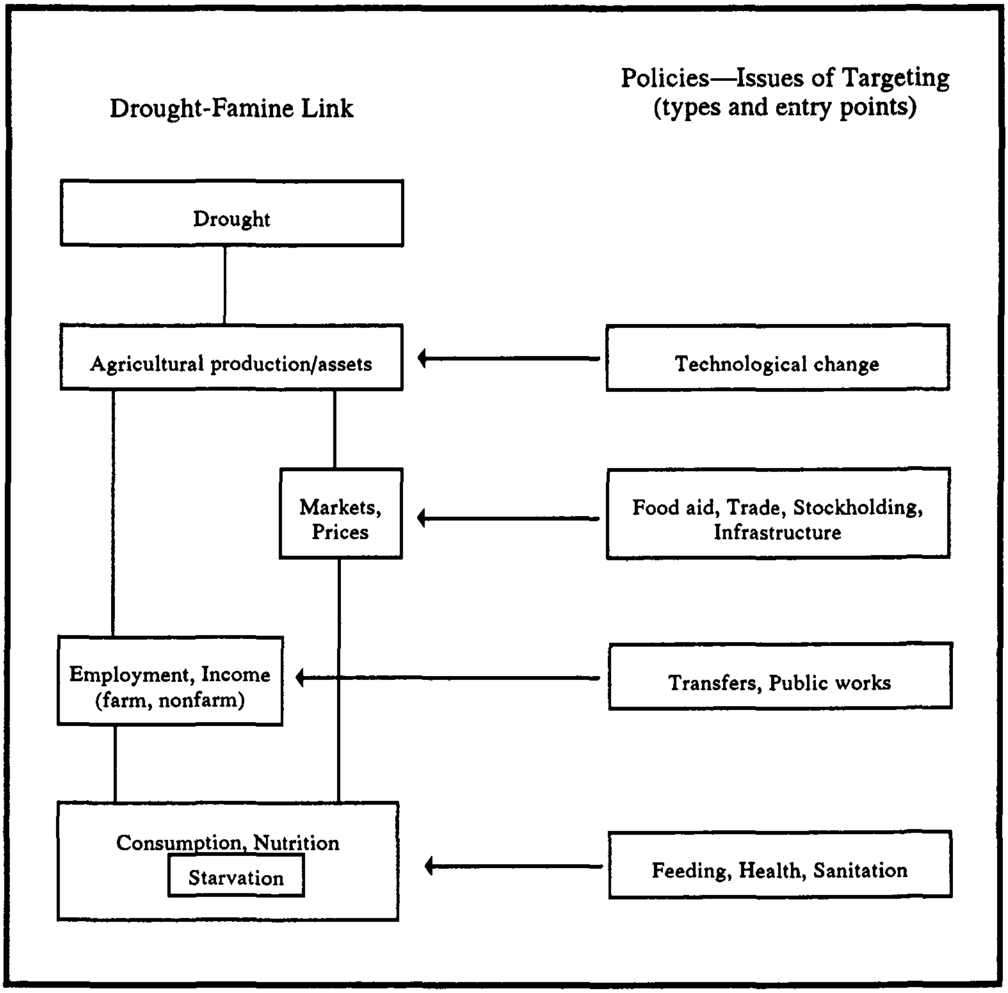


Figure 3—Overview of the focus of the analysis



that could be targeted at the various points of the drought-famine chain are identified. The principal relationships may be thought of as a set of recursive systems of equations defined as

$$Q = Q\,(W, P, Z_1, U_1) \qquad \text{production response,} \qquad (1)$$

$$P = P\,(Q, Z_2, U_2) \qquad \text{short-term price response, and} \qquad (2)$$

$$C = C\,(P, Y(Q), Z_3, U_3) \qquad \text{consumption response,} \qquad (3)$$

where

Q = production index,
P = price index,
C = consumption index,

W = weather index,

Y = income index,

Z_1 = nonweather and nonprice shifters,

Z_2 = nonproduction-related shifters,

Z_3 = nonprice and nonincome shifters, and

U_1, U_2, U_3 = error terms associated with production, price, and consumption equations.

It is obvious that complex trade-offs prevail between the indicated types of interventions in the short run and long run.

The presentation of the report follows the structure depicted in Figure 3. An overview of the record of drought and famine in Sudan's history is introduced in Chapter 3. It focuses especially on household and village experiences, based on IFPRI surveys and other primary data. The experience of the 1984-85 famine is highlighted with a discussion of its nature and effects and of the responses in the drought region of western Sudan. This is followed by a review of the development of agricultural production and a model relating rainfall to production at different levels of commodity and regional disaggregation. The impact of the 1984 drought is isolated to demonstrate the production effects of drought (Chapter 4). The behavior of prices and markets in a context of production shortfalls and famine in an environment of extremely weak interregional trade infrastructure is the focus of Chapter 5. The transitory food security problem (famine) grows rapidly out of the massive chronic food security and undernutrition problems. The effects of changes in prices and income on nutrient consumption are traced in Chapter 6. An assessment of the nutritional situation in the postfamine period shows the prevalence of undernutrition in the presence of inadequate food intake, poor community and health infrastructure, and low levels of human capital. Chapter 7 reviews past economic and famine policies—or the lack thereof—and draws lessons from the experience gained in coping with food crises in the 1980s through food aid and specific projects, again drawing mainly on original household-level survey information. Finally, conclusions are drawn regarding policy options that would be effective in coping with the adverse effects of drought, on both short- and long-term bases, to prevent drought from being a trigger for famine.

3

RECORD OF DROUGHT AND HOUSEHOLD-LEVEL CONSEQUENCES IN WESTERN SUDAN

The Historical Record

Drought and its consequences are historical as well as contemporary problems in Sudan. A careful review of the literature by Ibrahim (1985) shows that periods of drought have occurred throughout the history of Sudan, and in most cases these have been followed by famines and outbreaks of disease.[1]

An overview of droughts and related famines in the country is provided in Table 1. The earliest recorded famine occurred in 1684. The 1835-38 period is known as the "years of famine," particularly the year 1836, which is notable for widespread cholera that decimated a population already weakened by hunger (Hill 1970). The 1888-89 famine is considered to be the greatest famine, caused by two consecutive years of poor rains (Slatin Pasha 1896; Churchill 1899; Duncan 1952; Farwell 1967; Holt 1970) and by political instability and unrest. Hundreds of thousands of people died of hunger and disease. Rain was abundant the following year, but harvests were destroyed by locusts and other pests. The year 1913 also witnessed poor rains, but major famine was averted by importing corn and distributing it free (MacMichael 1934).

These records indicate diversity in the spatial incidence of drought and famine, with frequent occurrences concentrated in the western and eastern regions (Figure 4). A paucity of information and unbalanced documentation of historical events may be responsible for showing less frequency of drought in the western part of the country. In 1983, aware of these facts, Ibrahim (1985) investigated the drought experience of western Sudan. He relied on the memories of farmers, meteorological records, and fragmentary historical records to identify years of drought and famine. Farmers identified 36 years as years of drought and famine in the period between 1912 and 1974—26 years in eastern Kordofan and 18 years in eastern Darfur. Eight of these years were common to both areas. Seventeen of these years were given local names to describe sources of survival, scarcity of necessities, and magnitude of hardships. Fifty percent of these perceived periods of drought were meteorologically confirmed, with rainfall well below average. Records of rainfall failed to recognize the other years, perhaps, according to Ibrahim, because of the nature of rainfall in the semi-arid areas where rain is highly localized or because the recall of events by local inhabitants may be faulty.

Ibrahim's findings concur with historical records that 1913, 1914, and 1927 were drought years (Table 1), but these droughts actually spread from the eastern

[1]This chapter draws heavily on contributions of Mohamed Babiker Ibrahim (1985, 1990).

Table 1—Years of famine and drought in Sudan reported by historians

Years of Drought or Famine	Name and Damage	Areal Extent	Source
1684	"The great famine" (*Um Lahm*)	Sinnar region	O'Fahey and Spaulding (1974)
1835-38	"Years of famine"	Central Sudan	Hill (1970)
1836	Cholera spread through country	Central Sudan	Hill (1970)
1885	Slight famine	Central and eastern Sudan	al-Gudal (1983)
1888-89	Hundreds of thousands died	Central, northern, eastern, and western Sudan	Slatin Pasha (1896)
1888-89	No rain for a year, crops failed and grain became increasingly scarce. Prices rose to US$40 and then to US$60 for two sacks of dura (sorghum). People sold their children as slaves to save their lives and later bought them back with higher prices.	Central, northern, and eastern Sudan	Duncan (1952) Farwell (1967) Churchill (1899) Holt (1970)
1888-89	Thousands died of hunger and disease	Central, northern, eastern, and western Sudan	MacMichael (1934)
1890	Locusts and mice consumed the products	The Nile area	Farwell (1967) Duncan (1952)
1913	Poor rain, corn brought from India and issued free of charge in distressed areas and cheaply elsewhere	Mainly northern Sudan	MacMichael (1934)
1914	"The year of the flour" (flour brought from India because of poor rains)	Central Sudan	Henderson (1965)
1927	Slight famine	Central and eastern Sudan	al-Gudal (1983)

Source: Based on data from Mohamed Babiker Ibrahim, "Adjustment to Drought Hazard in the Semi-Arid Areas of the Sudan" (Ph.D. diss., University of Alberta, Edmonton, Alberta, Canada, 1985).

border of Sudan westward to Kordofan and Darfur regions. Moreover, Ibrahim added 1935, 1937, 1942, 1949, 1951, and 1957 as years of severe drought in Sudan. Shepherd (1988) identified 1932, 1938, and 1949 as years of severe famine through investigation of famine files for the period between 1932 and 1950. Combining these two sources, one would speculate that 1913-14, 1927, 1932-34, 1937-38, 1942, and 1949 were the years of most severe localized or nationwide famine in the country in this century up to the end of the 1950s. Occurrences of severe famine were fewer in the 1960s and 1970s, except for 1966, when famine was reported by farmers in the west. Of course, there could have been numerous unnoticed localized famines. Sudan largely escaped the worst years of the Sahelian drought of 1968-73 but experienced a major drought-related famine in 1984-85—about 100 years after the major drought of 1888-89.

Figure 4—Map of Sudan

Ibrahim also pointed out that drought and hunger are generally closely related in the western provinces, but the relationship is not a constant and necessary one. Failure of rains had nothing to do with the remembered food shortages in 1929, 1945, 1950, and 1959, which consistently show up in household-level surveys but do not coincide with actual rainfall information from the very same locations. Ibrahim suspects that it is probable that these food-shortage situations were due to insects, locusts, rodents, or plant diseases, or that local people were subjected to some kind of grain scarcity for social, administrative, or political reasons.

The Experience of Drought in the 1980s

The severe drought of 1984 was the culmination of a prolonged period of low rainfall that intensified after the end of the 1970s. According to Nicholson (1985), rainfall deficits for 1981 through 1984 equal or exceed those of the early 1970s in all Sahelo-Saharan, Sahel, and Sudan zones. Hulme (1984) also concluded, on the basis of observed rainfall data in the arid zone of Sudan, that the years from 1979 to 1983 were as dry as 1969-73. Recent findings (Eldredge et al. 1987) on western Sudan reveal that dry conditions have persisted in Northern Kordofan and Northern Darfur provinces since 1966. The authors attribute the downward pattern in annual precipitation to a decline in rainfall in July, August, and September—months that account for not less than 90 percent of annual rainfall. Moreover, they ascribe the decline in these months largely to fewer rainy days.

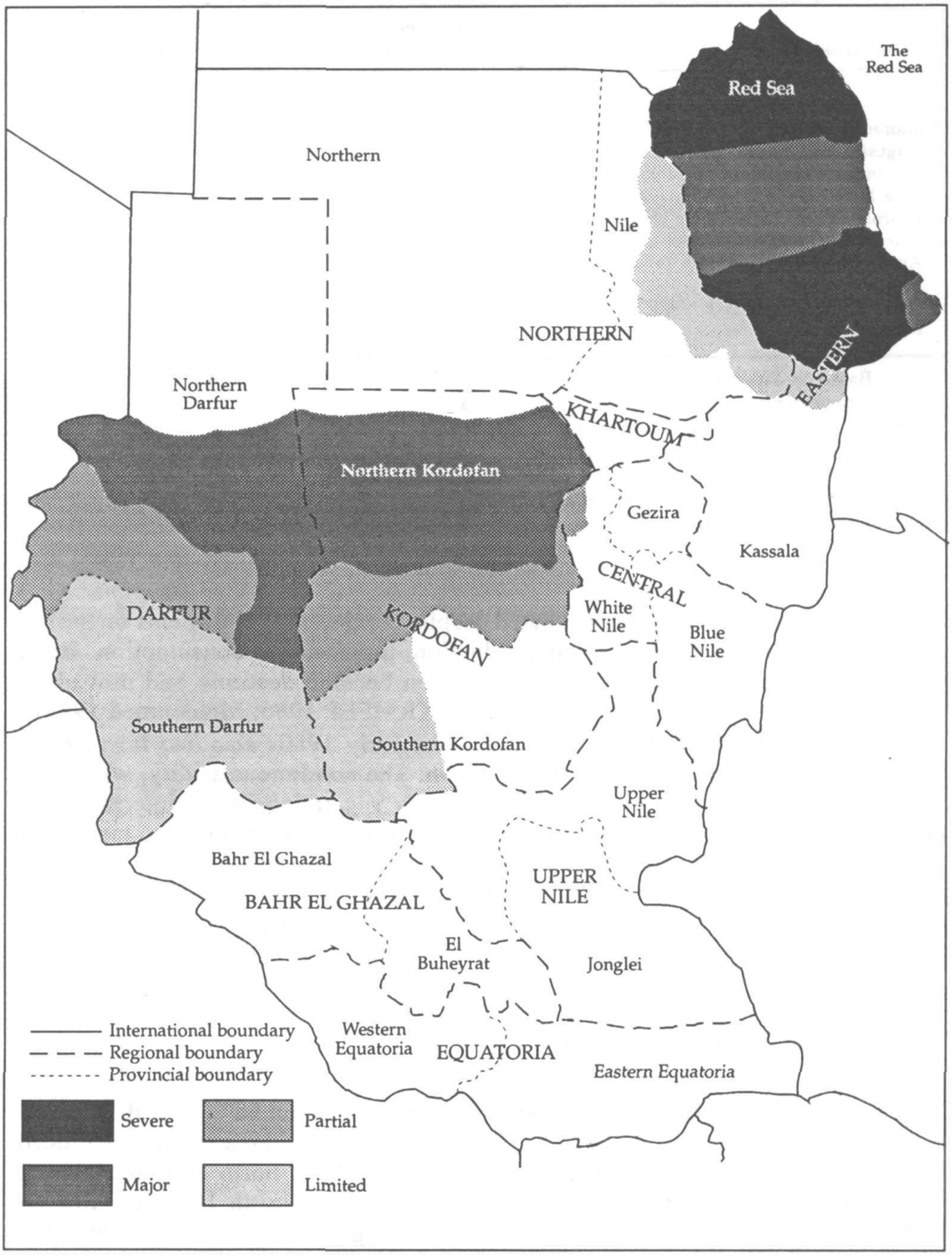
Information at the local level illustrates the development of dry conditions. According to a 1983 field survey, farmers and nomads in eastern Kordofan pointed out that the years between 1979 and 1983 were drought years (Ibrahim 1985). Households that migrated from Northern Kordofan and settled around Omdurman identified the period of 1980-84 as a severe dry period (Khalil 1987). The 1984 drought was the peak of the process that was set in motion in the late 1970s.

The main area affected by drought and desertification in Sudan is above 12° north latitude (Figure 5). In August 1984 Kordofan and Darfur had 2.8 million and 1.4 million, respectively, classified as affected population (Table 2). Of this affected population, those who lived above 13° north latitude were considered as severely affected. This group comprised 1.2 million in Kordofan and 0.8 million in Darfur. The reports of the United Nations Emergency Operation office for 1985 and early 1986 classified those at nutritional risk as vulnerable groups, especially pregnant and lactating women, and children under five years of age (OXFAM-UNICEF and Kordofan 1985a, 1985b, 1985c, 1986). These groups were estimated at more than 700,000 in Kordofan and about 800,000 in Darfur by mid-1985 (Pearson 1986).

Data on the magnitude of the displaced population are patchy. Available fragmentary information, however, indicates sizable displacements. By 1984, the population that had settled in the four major camps around Omdurman was estimated at 46,000 (Economic and Social Research Council 1988). Those camped on the outskirts of El Obeid were estimated at 45,000 by March 1985. There were an estimated 25,000 people living in the camps on the outskirts of Kosti by June 1985.

The agricultural households experienced large-scale erosion in their traditional income base, with few employment opportunities outside the rural economy.

Figure 5—Map of areas of chronic food insecurity in the mid-1980s, Sudan



Source: Based on a map received by the authors from the World Food Programme, Khartoum.

Note: Mapping of population groups by severity of food insecurity is based on a combination of ecological variation and measure of food gap by area.

Table 2—Estimates of drought-affected population in western Sudan, 1984-86

Region/Period	Affected Population[a]	Vulnerable Population[b]
	(thousands)	
Kordofan		
August 1984	2,819	1,168
November 1984	c	1,268
June 1985	2,830[d]	741[e]
February 1986	1,889[e]	...
Darfur		
August 1984	1,430	763
November 1984	c	763
June 1985	2,870[d]	752[e]
February 1986	1,212[d]	c

Source: Based on data from Roger Pearson, "Lessons from Famine in Sudan (1984-86)" (United Nations International Children's Emergency Fund, Khartoum, 1986, mimeo).
[a]Population that lived between 12° and 18° north latitudes.
[b]Population that lived above 13° north latitude.
[c]No information available.
[d]No definition of "affected" or "vulnerable" reported.
[e]Population at nutritional risk.

Large-scale entitlement failure occurred despite continuous adjustments on the part of the population to stabilize their production, income, and consumption. In extreme cases, some segments of the population became destitute and moved out from their villages en masse (de Waal 1987; KRMFEP 1986; Mohammed 1988).

The effects of the years of drought in the early 1980s also had far-reaching consequences on the ecosystem of the region. The continuous aridity, which was marked by a decline in the water table and low vegetation cover, intensified the process of desertification. The process was further exacerbated by human responses to the changing environment as farmers continued expansion of cultivation into marginal and fragile areas to make up declines in yields and resorted to generating income from the sale of tree crops to support their falling income (Ibrahim 1985).

The Case of Western Sudan

The western part of Sudan lies approximately between 08° 40′ and 20° north latitudes and between 22° and 32° 25′ east longitudes. The area north of 16° north latitude represents desert. The area between 14° and 16° north latitudes is semidesert. South of the semidesert, between 12° and 14° north latitudes, lies the Sahelian zone. The Sahel includes most of the region's agricultural population, who depend for their income on livestock and crop production. The Sudanic zone lies south of 12° north latitude.

The amount of rainfall decreases northward until it reaches the desert zone. Average annual rainfall is less than 100 millimeters in the desert. Mean rainfall ranges from 100 to 200 millimeters per year in the semidesert. North of the Sahel, where it is arid for 9-10 months, mean rainfall ranges from 200 to 400 millimeters a year. Annual precipitation ranges from 400 to 600 millimeters on average along the southern frontier of the Sahel. The latitudinal pattern of rainfall is modified by the existence of the Jebel Marra Highlands in Darfur.

The soils are sandy in the semidesert. They are more stabilized in the northern part of the Sahel—the *goz* belt. The soils become sandy loam in the middle and clay in the south. The alluvial wadi soils range from small pockets in the north to larger areas southward. The area around Jebel Marra is intersected by numerous seasonal streams and relatively rich wadi soils. These seasonal streams are used for cultivation and water harvesting, especially during drought years.

The northern parts of Darfur and Kordofan represent areas typical of arid and semi-arid zones. Population is sparse but relatively dense in areas with easy access to better soils and water points. Agricultural production potentials are continuously depleted due to ongoing desertification, which has been exacerbated by recurrent droughts (Ibrahim 1984). The poor resource base and low technology utilization contribute to low productivity. Undeveloped infrastructure, particularly transport systems, limits opportunities for integration into the larger but weak market economy (Swift and Grey 1989; Darfur Regional Government 1988).

Effects of Droughts in the 1980s

Western Sudan, particularly the northern part, experienced extremely low rainfall in the years between 1982 and 1984, with a record low in 1984 (see, for example, Figure 6). The effects of these drought years precipitated a large drop in agricultural production and income. Dramatic deterioration in economic conditions resulted in a severe and widespread decline in purchasing power, collapse in the asset base, large and unseasonal migration, and deterioration of nutritional status in 1984-85. Failure to generate or gain access to food, coupled with poor access to health facilities, contributed to increased morbidity and mortality rates in 1985.

Crop Production. Between 1982 and 1984, production of major crops (millet, sorghum, sesame, and groundnuts) declined sharply. The regional data for Northern Kordofan show a record low production in the 1984 crop year. Production of millet and sesame (the two most important crops in Northern Kordofan) reached lows of 14 and 10 percent, respectively, in 1984 relative to the 1974-81 level (Table 3). The drop in production was largely associated with the continuous decline in yield. Village-based studies in Northern Kordofan indicate the occurrence of severe crop failure in the drier northern areas. Ibrahim (1985) noted that crop yields were severely affected in the northern semidesert zone. Mohammed (1988) noted that there was a total crop failure in 20 villages in eastern Kordofan in 1984/85. An IFPRI survey in Kordofan villages shows sizable crop failure, even in the middle Sahelian zone (Table 4).[2]

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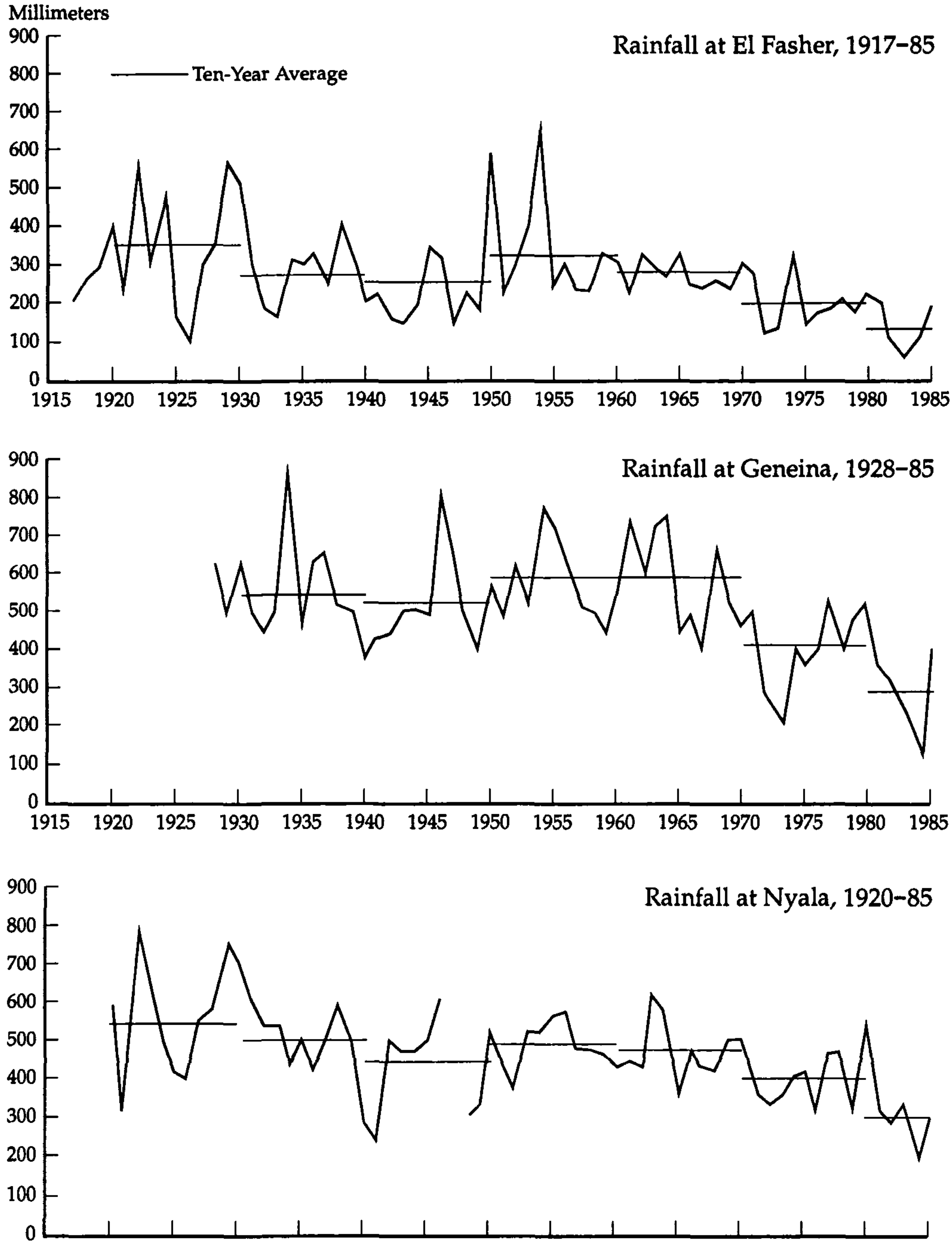
[2]The IFPRI survey covered 240 sedentary households in 10 villages of Bara and El Obeid districts in 1989. Villages were sampled to reflect variations in the 1984-85 drought-related famine experience, their degree of involvement in rehabilitation projects, and access to water sources and main towns. A sample of households was drawn from the project-based stratified frame of participants and eligible nonparticipant households.

Figure 6—Rainfall at selected sites in western Sudan, 1917–85



Source: Jeremy Swift and John Grey, "Report on Darfur Region Food Security Policy and Planning" (Institute of Development Studies, University of Sussex, Sussex, 1989, mimeographed).

Table 3—Index of production, area, and yield of major crops in Northern Kordofan, 1974-85

Source/Crop	Index 1974-81	1982	1983	1984	1985	Average, 1974-81
						(1,000 metric tons)
Production						
Millet	100	38	46	14	151	146.6
Sorghum	100	54	20	8	19	100.1
Sesame	100	61	42	10	73	66.9
Groundnuts	100	32	22	6	24	189.8
						(1,000 feddans)
Area						
Millet	100	97	106	135	177	1,136
Sorghum	100	92	91	62	36	486
Sesame	100	79	81	74	81	859
Groundnuts	100	78	69	53	21	723
						(kilograms/feddan)
Yield						
Millet	100	39	43	10	85	130
Sorghum	100	61	23	13	56	198
Sesame	100	76	51	13	89	79
Groundnuts	100	41	32	11	112	207

Sources: Sudan, Ministry of Agriculture and Natural Resources, *Yearbook of Agricultural Statistics* (Khartoum: MANR, 1970, 1984, 1987); and Sudan, Ministry of Agriculture and Natural Resources, *Current Agricultural Statistics: 1984/85 and 1985/86* (Khartoum: MANR, 1988).

Table 4—Household crop production in 10 Kordofan villages, 1983-88

Crop/Season	Percentage of Area Harvested	Output per Area Planted	Output per Capita
		(kilograms/hectare)	(kilograms/person)
Millet			
1983	82	101	83
	(0.31)	(0.77)	(1.13)
1984	17	6	4
	(2.32)	(4.20)	(4.12)
1985	78	118	97
	(0.33)	(0.89)	(1.35)
1987	37	26	18
	(1.25)	(2.16)	(2.84)
1988	82	124	80
	(0.32)	(0.81)	(0.99)
Sesame			
1983	80	86	64
	(0.31)	(0.92)	(1.43)
1984	25	8	6
	(1.89)	(3.89)	(3.67)
1985	70	70	46
	(0.42)	(0.93)	(1.29)
1987	86	79	58
	(0.26)	(0.87)	(1.30)
1988	85	75	50
	(0.28)	(0.79)	(1.07)

Source: International Food Policy Research Institute survey, 1989.
Note: Figures in parentheses are coefficients of variation.

Farmers in Northern Darfur also experienced years of consecutive crop failures in the 1980s (Ibrahim 1990). Occurrence of crop failures was noted in some parts of Northern Darfur in 1982 and 1983; for example, Um Kaddada Area Council in the east. However, the crop failure of 1984 was severe and extensive. Production of millet, the main staple food for the inhabitants of Northern Darfur, reached a low of 14 percent in comparison with the 1981 level. The average yield reached 18 percent of the normal level in the same year. Despite improvement in total rainfall in 1985, some areas of Northern Darfur continued to experience crop failure.

Stock of Animals. Poor grazing and health conditions, which worsened in 1984, resulted in large livestock losses. The 1984-85 period witnessed a sharp decline in growth rates of herds due to high mortality rates, distress sales, and low birth rates. Estimates of livestock losses in IFPRI survey villages indicate that herd size, which averaged about 2.0 livestock units per capita by the end of 1983, dropped to 0.26 units by the end of 1985—a drop of 86 percent (Table 5). The largest drop occurred in the case of cattle. By the end of 1985, the share of cattle in herd composition was 2.2 percent. Goats, on the other hand, gained a more prominent position—as much as 52 percent, compared with 35 percent at the end of 1983.

Mortality rates were relatively high for the less drought-resistant animals—cattle and sheep (Table 6). Cattle and sheep require relatively shorter drinking intervals (3-5 days)—much shorter than camels, which are served in intervals of 9-15 days. Sheep are also selective in their grazing behavior, both in type of feed and timing of feeding. Cattle and sheep were highly vulnerable to poor pasture and water conditions and a worsening disease environment. The young and the pregnant or lactating females were the most vulnerable in all species, causing great damage to future restocking capacity. According to the 1986 official survey in northern and eastern Kordofan, the losses were much greater in the northern arid zones, where shortage of pasture and water was intense (KRMFEP 1986).

Table 5—Herd size and distribution among rural households in Kordofan, 1983-88

Item	1983	1984	1985	1987	1988
Livestock per capita (LSU)[a]	1.91	0.62	0.26	0.31	0.36
			(percent)		
Herd composition					
Cattle	37.12	23.26	2.21	1.44	1.11
Sheep	6.75	4.33	4.28	3.68	4.59
Goats	34.57	38.54	51.96	55.88	56.51
Donkeys	13.07	17.64	28.84	24.40	23.19
Camels	8.49	16.23	16.71	14.60	14.60
Livestock-owning households					
Cattle	58.0	25.0	3.6	2.7	2.7
Sheep	18.4	7.6	5.1	5.4	7.5
Goats	83.7	56.9	61.6	74.8	83.7
Donkeys	77.6	42.4	41.3	55.8	60.5
Camels	43.5	29.9	24.6	23.1	25.6

Source: International Food Policy Research Institute survey, 1989.
[a]In livestock units, cattle = 0.83, goats/sheep = 0.20, camels = 1.0, and donkeys = 0.50.

Table 6—Change in growth rate and growth components of livestock in Kordofan, 1983-88

Species	Year	Growth Rate	Growth Component: Birth Rate	Mortality Rate	Net Off-take[a]	Other Losses[b]
			(percent of change)			
Cattle	1984	-73.0	15.1	-47.9	-25.8	-14.5
	1985	-92.0	1.9	-53.0	-23.0	-18.0
	1986	-8.6	20.0	-8.0	-16.6	-4.0
	1987	17.4	21.7	-4.3	0.0	0.0
	1988	22.2	25.9	0.0	-7.4	3.7
Sheep	1984	-80.5	21.3	-45.8	-44.4	-11.6
	1985	-57.3	11.5	-27.1	-26.0	-15.6
	1986	14.6	31.7	-4.9	4.8	-17.1
	1987	6.4	38.3	-17.0	-8.5	-6.4
	1988	16.0	n.a.	n.a.	n.a.	n.a.
Goats	1984	-65.0	25.6	-31.4	-33.2	-26.1
	1985	-14.3	54.1	-34.2	-19.1	-15.1
	1986	24.6	70.8	-11.6	-19.0	-15.6
	1987	14.9	74.9	-21.1	-23.7	-15.2
	1988	17.5	70.2	-23.9	-17.0	-11.9
Camels	1984	-45.6	0.9	-26.3	-17.5	-2.6
	1985	-27.4	1.6	-19.4	-6.5	-3.2
	1986	13.3	13.3	-4.4	4.4	0.0
	1987	9.8	11.8	-3.9	7.8	-5.9
	1988	16.1	12.5	-1.8	3.6	1.8

Source: International Food Policy Research Institute survey, 1989.
Note: n.a. means not available.
[a]Net off-take equals sales minus purchases.
[b]Other losses include slaughtering, gifts, thefts, and unspecified disappearances.

Birth rates were too low in these years to offset the high losses. Production response indicators in Table 7 show that calving intervals and suckling periods are longer and growth is slower in drought years. Poor physical condition due to starvation and disease, and the need to suckle offspring for a longer period contribute to a shorter calving interval. This is evident from much-reduced birth rates in the 1983-85 period. And the animals that were born were slow to reach maturity. The natural process was thus self-regulated to maintain pace with the surrounding environment.

A similar pattern was evident in Darfur. Animal losses were much higher in the north than in the south. For example, 71 percent of the cattle and 40 percent of the goats in the north were lost. The south lost 37 percent of the cattle and 10 percent of the goats. The camel-herding nomads of the north suffered the most. Ibrahim (1990) noted losses of as much as 70-90 percent of camels among the camel herders, particularly the Medub tribe. The sedentary farmers also witnessed a sharp drop in their livestock. Among sedentary farmers interviewed in Northern Darfur, 44 percent reported loss of all their sheep and 14 percent reported total loss of goats (Ibrahim 1990). Less than 10 percent of the sample managed to maintain their herds throughout the drought years.

Table 7—Variation in animal production response between normal and drought years in Southern Darfur

	Age at Maturity		Suckling Period		Calving Interval	
Species/Sex	Normal Years	Drought Years	Normal Years	Drought Years	Normal Years	Drought Years
			(months)			
Cattle						
Male	43.2	62.7	. . .	. . .	. . .	. . .
Female	38.8	59.2	7.8	14.1	12	23
Sheep						
Male	10.7	15.3	. . .	. . .	. . .	. . .
Female	8.6	15.4	4.8	7.9	7	13
Goats						
Male	7.1	12.3	. . .	. . .	. . .	. . .
Female	7.4	11.8	4.3	7.7	7	11

Source: Sudan, Ministry of Agriculture and Natural Resources, *Pilot Survey of Livestock Production and Marketing in Southern Darfur: With Emphasis on 1983-85 Drought Effects (Khartoum: MANR, 1987).*

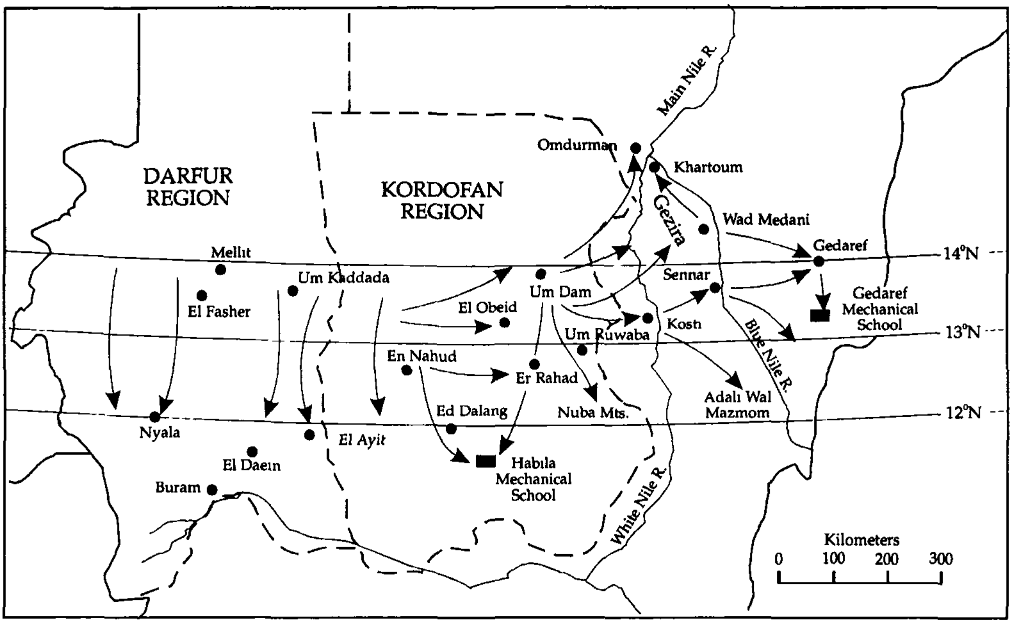
The effects of large losses are evident in the ownership of livestock in the postdrought years. In 1985, livestock assets in 10 IFPRI survey villages in El Obeid and Bara districts of Northern Kordofan reached 14 percent of their 1983 level. By 1988, they had recovered only to 19 percent of the 1983 level. The gradual buildup has shown an increased concentration on low-cost and drought-enduring animals.

Distress Migration. The nomads have adjusted their seasonal movements over the years in response to periodic drought conditions. In normal years, the camel-herding nomads of the north move their herds northward at the onset of the wet season. At the end of the wet season, they move the herds southward toward the southern fringe of the semidesert belt (around 14° north latitude) or to the Sahelian belt (12° north latitude to 14° north latitude) and settle around water points during the dry season. The cattle owners of the south move northward at the onset of the rain as far as 13° north latitude and stay below 10° north latitude during the dry season.

A baseline survey in Sodari district in Northern Kordofan reveals that the northern pastoralists have increasingly shifted their southward movement (*darat* grazing) to October instead of beginning it as late as January (el-Sammani et al. 1984). Ibrahim (1985) also noted from a sample of nomads that since 1979, 43 percent had changed the areas where they spent the dry months. In recent years the northern nomads of Kordofan have intensified their penetration deep into the south below 12° north latitude. By 1983, for example, the Kababish tribe of the north was found deep in the southern reaches of Kordofan (el-Sammani et al. 1984).

Distress migration was also observed among the northern nomads in Darfur in the 1983-85 period (Figure 7). Most of the Medub tribe lost their camels and moved to eastern Darfur to work as agricultural laborers or to a relief camp in Mellit town. The Zaghawa tribe started to migrate from their tribal land at the end of 1983 and settled south of El Fasher with their relatives who had moved earlier, during the droughts of the 1970s. They also migrated to areas in Southern Darfur (Buram and

Figure 7—Migration trends of peasant farmers in the semi-arid and central parts of Sudan



Source: Based on data from Mohammed Babiker Ibrahim, "Adjustment to Drought Hazard in the Semi-Arid Areas of the Sudan" (Ph.D. diss., University of Alberta, Edmonton, Alberta, Canada, 1985).

El Daein) and outside the region to Omdurman and the irrigated scheme in Gezira Province. The Zayadia nomads also moved from Mellit to Southern Darfur and the El Daein area.

High rates of migration were also recorded in the Kordofan sedentary sample (Table 8). In one village, as many as 95 percent of the IFPRI sample families had at least one migrant member, the rate of migration per family reached a high of 89 percent, and whole-family migration reached 74 percent. Large-scale movements involving whole families were also evident in other parts of the region. A study among sedentary farmers in eastern Kordofan revealed that, from a low of 14.7 percent in 1980/81, the percentage of households that migrated with whole families reached 45.9 percent in the peak drought year of 1984/85 (Mohammed 1988).

There are some notable developments in the postfamine period. First, the whole-family migration rate dropped considerably in the years following the 1984-85 period. Second, high proportions of rural families continue to migrate in comparison with their migration in prefamine years. However, the migration rate per family has come back down to the level of the prefamine period. Third, migration continues to be seasonal and of short duration, except for international migrants, who are often young men with a better financial base.

Employment and Income. The decline in production that occurred in 1984 translated into a large drop in farm employment. Despite an expansion of area planted, especially millet fields, farm employment dropped after planting by an average of 70-75 percent from a normal (four-year moving average) level (Table 9).

Table 8—Short-term migration rates for selected survey villages in Kordofan, 1983-88

Village/Year	Percentage of Families with at Least One Migrant	Rate of Migration: Migrants per Family	Rate of Migration: Whole Families
		(percent)	
Abukhrais			
1983	25	12	8
1984	42	15	8
1985	67	44	29
1987	42	14	4
1988	50	19	17
El Felia			
1983	33	23	14
1984	48	36	29
1985	67	52	48
1987	43	21	10
1988	52	23	10
Wed Eldeik			
1983	11	7	0
1984	43	38	37
1985	95	89	74
1987	48	19	5
1988	33	18	5

Source: International Food Policy Research Institute survey, 1989.

Table 9—Farm size, labor use, and value of crop output in Kordofan, 1983-88

Crop/Season	Farm Size	Labor Use	Employment per Farm	Current Value of Output per Capita	Constant Value of Output per Capita in 1983 Prices
	(hectares)	(man-days/ hectare)	(man-days)	(SD£)	
Millet					
1983	4.4	20.0	88	51	51
1984	4.0	6.3	25	6	4
1985	4.4	18.2	80	43	49
1987	3.1	14.0	43	31	41
1988	4.2	18.5	78	121	59
Sesame					
1983	3.7	24.7	91	71	71
1984	2.6	8.6	22	8	6
1985	2.9	18.4	54	71	81
1987	4.3	16.4	71	108	142
1988	3.9	27.5	107	140	68

Sources: International Food Policy Research Institute survey, 1989; and Abdel Latif Ijami and Ronald D. Krenz, *Crop Production, Costs and Returns to Family Land in the Traditional Rainfed Areas of Sudan: A Five-Year Summary, 1984/85-1988/89* (Khartoum: Ministry of Agriculture and Natural Resources, 1990).

Typically, 17 percent of millet labor and 22 percent of sesame labor in Northern Kordofan comes from nonfamily labor in a normal year. Landless as well as capital-constrained landowning families often work in the villages for wages. Abandonment of farm work in 1984, therefore, hit these groups hard. A study that traced the rate of off-farm agricultural employment of sample participants in eastern Kordofan also supports a substantial decline in employment opportunity (Mohammed 1988). The percentage of families who worked as local agricultural laborers dropped from 18 percent in 1983/84 to 3.1 percent in 1984/85.

The large drop in employment occurred at the same time there was a glut of people seeking work. The decline in agricultural income as well as asset position precipitated a large drop in farmers' reservation wages, which translated into high entry into the labor market. Increased participation of women in the labor force was particularly notable. The women from IFPRI survey villages, for example, engaged in housekeeping employment in urban areas—a type of work not customary in Sudanese culture. Wage rates consequently fell in rural labor markets. In the survey area, for example, a day of labor could buy only 2 kilograms of millet in 1984, compared with 6 kilograms in 1983.

There was a nearly complete collapse in crop income, which normally accounts for one-third of household income. Moreover, since nearly half of household income is from rainfall-dependent agricultural income sources (crop production, local farm wage employment, and livestock), the extent of income failure was much greater. When farmers faced a severe decline in their agricultural income, they resorted to sale of assets, collected products, and nonagricultural income. A sizable fraction of the sample derived their income primarily from liquidation of assets and nonagricultural income sources (handicrafts and wage labor). Loans and transfer receipts also enhanced income. Those in a better wealth position engaged in large-scale selling of their assets (livestock and other household valuables). The asset-poor had to depend greatly on handicrafts and transfers to augment their low income from sale of assets.

Demographic Effect. By and large, the 1984-85 famine contributed to slow growth in the population of the survey villages. The natural growth rate dropped from an annual rate of 2.7 percent in 1983/84 to 2.3 percent in 1984/85. However, a high rate of out-migration, especially in the short run, caused a large drop in village population. A most notable case was in Bara district villages, such as Um Sot, where the resident population dropped appreciably because of large-scale emigration.

No significant excess mortality rate was evident in the survey villages in 1985—the year when demographic change could be presumed to show a sizable shift. The crude mortality rate increased, but not as progressively as expected in a period of low food intake and high incidence of disease. Thus, the expected increase in the spread between high mortality and low fertility was not evident in the survey villages. This fails to concur with de Waal's (1987) findings for Darfur, the region further to the west of Kordofan, of a decline in the natural growth of village population due to an excess mortality rate coupled with a decline in birthrate.

These results are, of course, specific to study areas. Various pieces of evidence point out that significant demographic change has occurred in the much drier areas of Northern Kordofan. Estimates of famine-related deaths are tentative. There is strong evidence of a permanent out-migration to the central zone of Kordofan, and to the Central and Eastern regions of Sudan (Khalil 1987; Ibrahim 1985, 1990). High net permanent out-migration must have been a strong factor in depopulation of these hard-hit areas.

Household-Level Coping Strategies

There is emerging evidence that provides insights into household coping behavior in periods of food crisis (see, for example, Jodha 1978; Corbett 1988; von Braun and Teklu 1989; Campbell 1990). Corbett, for instance, synthesizes existing knowledge of strategies and responses common in African settings. Von Braun and Teklu reexamined these responses in the context of three African countries (Rwanda, The Gambia, and Sudan) in order to understand interhousehold variations in success of coping with crises and with regular and predictable situations.

Studies on Sudan (de Waal and el-Amin 1986; de Waal 1987; Osborne et al. 1986) point out some common coping features: increased rate of migration, including whole families; shift in income sources toward sale of livestock, personal possessions, and transfers; reduction in frequency and size of meals; greater consumption of tree fruits; and greater dependence on markets for acquisition of food and sale of labor. Intrahousehold food-sharing and transfers are more common among relatives.

The findings of this study are not conclusive as to the specific ordering of these responses (Table 10), but there are notable patterns. Household responses involve substitutions between and within consumption-income and asset paths. There are discrete shifts in these paths (strategies), but responses are simultaneous across the paths. Households vary in their emphasis on choices among these strategies and responses. In general, they prefer to avoid action that would endanger their future survival. However, coping success is unequal across households because of an unequal endowment base, unequal access to a community risk-sharing network, and unequal public support.

Production Response. Farmers in general prefer to maintain diversified crop portfolios. Typically, a few crops dominate, and these are often a mix of staple and cash crops (Table 11). This was the case in the Kordofan sample despite higher relative factor returns of sesame to millet (on the order of 1.4 to 1) in the 1987 and 1988 seasons. Other considerations also enter into the choice of crop mix. Where market transaction costs are prohibitive, as in the case of western Sudan, farmers prefer to maintain food crops in their crop portfolios. Diversity in crop mix also allows farmers to follow a flexible production schedule in terms of their responses to varying rainfall patterns. Typically, farmers in the west shift from millet to other crops (for example, sesame and watermelon) when early rains appear to be inadequate or when rains are concentrated in the latter part of the wet season (late July and August).

In addition to the crop-diversification response, farmers adopt a variety of loss-avoidance or loss-minimization measures. They shift their planting date to before the onset of the first rains (*remail*) to get maximum moisture from a short and intense rainfall. Because of high local variability of rains, it is common to plant each crop in several different locations of different fields. Crops are also planted in larger areas, when land availability permits, to ensure that some area is harvested

Table 10—Time path of drought-coping responses in western Sudan

Source of Adjustment	Stages of Response: Early	Intermediate	Final
Production	Change in cropping and planting practices	. . .	. . .
	Increased nonfarm home production		
Labor	Migration in search of employment	Migration in search of employment (intensified in face of falling expected wage rate)	Distress migration
		Separation of family	Separation of family (possibly permanent)
Assets/capita	Sale of small stock (liquid, easily reversible)	Sale of productive assets (livestock, tools, land) in depressed market	. . .
	Sale of large stock (nonessential)		
Loans/transfers	Use of interhousehold transfers and loans	Credit from merchants and moneylenders	Donation (relief assistance)
Consumption	Switch in expenditure/dietary composition	Reduction of consumption (greater dependence on market)	Reduction of consumption (survival may be threatened)
	Reduction of current consumption level (cut in frequency or size of meals or both)		
	Adjustment in intrahousehold allocation		

at the end. Adoption of quick-maturing seed varieties is also on the rise because of the recurrence of droughts (Ibrahim 1985).

Migration Response. Movements of the sedentary agricultural population are characterized in normal years by dry-season migration of working persons. Normally, the sedentary cultivators leave their farms at the end of the harvest period (December or January) and return in April or May to prepare their own farms. In short, migration is voluntary, seasonal, and involves adult members of a household. The migration rate per household ranges from 13 to 20 percent in normal years.

However, large-scale movements began soon after the farmers realized that the 1984/85 crop year was a complete failure. According to a survey of displaced households from western Sudan who settled around Omdurman, 74.9 percent came in September and October (Table 12)—much earlier than the normal January to May dry-season migration.

Table 11—Crop diversification of farm households under drought in Kordofan, 1983-88

Crop	Season	Share of Farms Growing the Crop[a]	Share of Value of Production
		(percent)	
Millet	1983	84	32
	1984	23	31
	1985	83	23
	1987	41	13
	1988	91	41
Sorghum	1983	4	10
	1984	8	18
	1985	25	8
	1987	30	14
	1988	48	9
Sesame	1983	84	49
	1984	28	33
	1985	89	48
	1987	90	43
	1988	93	47
Watermelon	1983	...	4
	1984	...	16
	1985	...	6
	1987	...	16
	1988	...	4

Source: International Food Policy Research Institute survey, 1989.
[a]Only those who participated in the production process up to and including harvesting are considered as participants.

Table 12—Arrival time of displaced population around Omdurman, 1984

Month	Percentage of Population
March	0.9
July	3.0
August	5.6
September	34.0
October	40.9
November	10.4
December	5.2

Source: Based on data from S. S. Khalil, *The Socioeconomic and Political Implications of the Environmental Refugees in the Vicinity of Omdurman*, Monograph 6 (Khartoum: University of Khartoum, Institute of Environmental Studies, 1987).

Migration in Northern Kordofan took different directions, but because of diminished farm-employment opportunities, the emphasis was toward nearby towns and major cities. The study in eastern Kordofan shows that the percentage of migrants who moved to urban areas (mainly Omdurman and Um Ruwaba) peaked at 63.8 percent in 1984/85 from the preceding four-year average of 5.4 percent (Table 13). A survey of displaced population from eastern Bara, eastern Sodari, and Um Ruwaba districts showed that 40, 53, and 45 percent, respectively, of the district's total population moved to nearby towns and Khartoum (Table 14).

Notable changes have also been observed in the migration pattern of the sedentary population during recent droughts. In Darfur, large-scale migration was directed to the better rainfall areas of the south, especially to the Jebel Marra Highlands and surrounding alluvial plains. Others moved to the larger cities of Northern and Southern Darfur—El Fasher, Nyala, and Zalengi. Those without prior experience of migrating for seasonal work and resource base opted to move either to areas where they had relatives or access to casual work or to famine-relief camps.

These variations in migration responses indicate the important influence of proximity to urban areas, ecological variation (for example, presence of vegetation as a source of direct food and cash income), and distance to water points. Distress migration was high in areas where the agricultural resource base was limited, alternative income sources were absent, and critical survival food was not easily affordable and accessible. Also, where the social support network was discriminatory (as was the case for recent residents in some villages), the disadvantaged were forced to migrate.

In addition, there were household-specific factors that contributed to out-migration. An attempt to capture these variables was made in the context of a dichotomous logit decision model. The estimated (log) odd-ratio parameters and associated mean-level evaluated probabilities provide additional insights on the decision to migrate or not (Table 15).

Table 13—Percentage and destination of migrants from sedentary households in East Kordofan, 1980/81-1986/87

	Household Migrants		Destination of Migrants		
Season	One Person	Whole Family	Urban	Gezira	Rainfed Area
			(percent of households)		
1980/81	10.7	14.7	4.2	89.3	6.5
1981/82	10.6	15.8	4.7	77.5	17.8
1982/83	13.0	17.3	5.2	48.9	45.9
1983/84	11.2	15.3	7.6	40.7	51.7
1984/85	7.7	45.9	63.8	26.6	9.6
1985/86	21.0	10.0	41.1	22.7	36.1
1986/87	21.4	7.0	44.4	16.9	38.7

Source: Based on data from Mohammed Abdel Gadir Mohammed, "The Impact of Emergency Food Aid on Traditional Agricultural Production Systems—The Case of East Kordofan District" (M.S. thesis, University of Khartoum, 1988).

Table 14—Percentage of population migrated from East Bara, East Sodari, and Um Ruwaba, by destination, 1984-85

District/Village of Origin	Migrants	Destination					
		Adjacent Villages	Nearby Towns	Southern Kordofan	Khartoum	Gezira	Other
	(percent of population)	(percent of village migrants)					
East Bara							
Malagat (Risa)	30	12	24	20	13	11	20
Abu Shouk	56	12	16	8	26	19	19
El Saafa	27	9	12	13	29	21	16
East Sodari							
El Shatoot	42	2	11	6	48	24	9
Um Surra	82	6	23	13	31	20	7
Sowdary	25	3	14	17	36	21	9
Tenna	35	6	13	11	31	22	17
Hamrat El Wiz	18	6	21	11	36	14	12
El Hagab	50	6	21	8	36	20	8
Huffra	7	6	18	6	26	22	22
Um Khirwi	11	7	20	9	39	13	12
Um Ruwaba							
Brima Elnar	42	12	34	18	14	10	12
Tip El Haloof	20	19	29	11	21	11	9
Um Ruwaba	15	13	33	20	17	9	8
Koz El Bagara	43	14	33	21	13	9	10
El Malaga	48	12	22	17	17	16	16
Shurkaila	6	4	29	20	16	14	17
Gabsha	12	12	29	20	15	12	12
Braissa El Ragig	50	9	11	10	28	32	10
El Simeh	9	3	16	14	29	20	18

Source: KRMFEP (Kordofan Regional Ministry of Finance and Economic Planning), *The Current Situation of Livestock in North Kordofan—Part I* (El Obeid, Kordofan: KRMFEP 1986).

- The odds are higher for migration of families headed by males than for those headed by females.
- Ownership of livestock reduces the probability of out-migration. It is the poor who are prone to migrate.
- Families with large numbers of dependents are most likely to migrate, indicating distress migration.
- The odds of migrating are higher where there is no access to a water source within a village.
- In addition to the aforementioned factors, others contributed to high out-migration in two IFPRI survey villages that experienced high rates of migration during the peak of the famine. These are captured in the dummy variables and may reflect differential access to vegetation (pasture, free crops) and access to outside sources of income such as remittances.

Livestock Response. The desire of farmers to protect a minimum viable number of their livestock to ensure continuity of future productive capacity was evident in their actions in 1984-85. They pursued a course that involved extensive change in feeding sources and practices, a shift in the composition of livestock varieties, and the movement of animals to areas perceived to have better pasture and water.

Table 15—Maximum likelihood estimates for short-term migration of survey households, logit model

Explanatory Variable	Parameter Estimate (t-Statistic)	Change in Probability[a]
Age of head of household (in years)	-0.02 (-0.18)	. . .
Sex of head of household (1 if male, 0 otherwise)	1.20 (2.54)*	. . .
Migration experience (1 if migrated in previous season, 0 otherwise)	18.59 (0.01)	. . .
Per capita livestock, 1983 (LSU)[b]	-0.74 (-2.98)*	-0.0159
Adult-to-family ratio	-2.24 (-4.00)*	-0.0480
Water source (1 if village has permanent water source, 0 otherwise)	-1.79 (-4.86)*	. . .
Village dummy (1 if village experienced large-scale migration, 0 otherwise)	4.55 (11.60)*	0.0975
Constant term	-2.23 (-2.96)*	
Log LF[c]	-145.0	

Source: International Food Policy Research Institute survey, 1989.
[a]Evaluated at sample mean point.
[b]LSU = livestock unit.
[c]An alternative measure of goodness of fit involves a correct classification of households as either migrating or not. The model correctly classified 95.4 percent of the households.
*Significant at the 99 percent confidence level.

Variations between these principal responses were conditioned on the rapidity and intensity of the drought, market conditions, and the resource capacity of the farm population.

A great majority of the farmers in the survey area attempted to make up the shortage of pasture by shifting to purchased feeds (at times this was done by selling part of the livestock) or collected plants. Farmers also split their stocks, sending some to distant areas for better grazing—a practice rarely followed by sedentary farmers, particularly small-herd owners. However, access to permanent water yards and better pasture routes was often limited to those who had a financial advantage or social ties. As the drought continued, farmers' capacity to feed their animals was increasingly constrained by shortages of pasture and water and rapidly declining income capacity. Farmers had to dispose of their more valuable animals to fetch the best price possible in the depressed market or to avoid imminent loss due to livestock death.

The farmers engaged in large-scale dispossession of their livestock. The off-take rates for these animals were much higher than the normal rates (Table 16).

Table 16—Livestock losses among sedentary farmers in East Kordofan, 1984-85

Species	Death	Sale
	(percent)	
Cattle	70.0	30.0
Sheep	65.0	35.0
Goats	78.0	22.0
Camels	82.0	18.0
Donkeys	96.0	4.0

Source: Based on data from Mohammed Abdel Gadir Mohammed, "The Impact of Emergency Food Aid on Traditional Agricultural Production Systems—The Case of East Kordofan District" (M.S. thesis, University of Khartoum, 1988).

Note: The estimated off-takes from the livestock population in El Obeid market in 1982 were cattle, 19 percent; sheep, 10 percent; goats, 3 percent; and camels, 8 percent (Louis Berger International 1983).

Such increased off-take was made possible by the sale of animals that often had not been destined for market. The normal preference is to sell adult males, cows that cease to produce or fail to give regular birth, and calves that are considered in excess of what is necessary for replacement of stocks. This selectivity process diminished in the 1984-85 period as farmers were forced to dispose of their animals. These animals, weakened by starvation and disease, often fetched low prices in the already depressed market.

Income Response. Farmers in the survey villages derive their income from diverse sources, principally crop and livestock production, collected products, transfers, and wage income. Within these income sources is a multitude of individual sources, but a few of them always dominate.

The relative position of these income sources in household income in 1988 is shown in Table 17. Eighty-five percent of the average income is earned income. Among agricultural income sources, crop production accounts on average for 30 percent. When it is combined with farm wage income, the average moves close to 37 percent. If livestock income is added, the average reaches 50 percent. Thus, about half of the income of the survey population comes from rainfall-dependent agricultural sources. The other important source of earned income is the sale of collected products (firewood, poles, charcoal, and grass). Transfers play a crucial stabilization role in a period of falling agricultural income—a recurrent event in recent years.

A comparison of mean income variations shows significant disparity; the high-income tercile has an income level that is four times higher than that of the low-income tercile (Table 17). Female-headed households make less income on average than male-headed households. Although poverty is widespread, it is not uniform among the farm population.

No considerable differences are seen between high- and low-income groups in their income composition, especially within earned-income categories. However, there are important variations in the income shares of transfers and collected products. Across genders, the important sources of differences are in crop and transfer incomes. Crop production is a relatively significant income source for male-headed households. Female-headed households tend to compensate for their

Table 17—Shares of income sources, by income group and sex of family head, 1988

Income Source	Whole Sample	Income Group: Low Tercile	Income Group: High Tercile	Family Head: Male	Family Head: Female
			(percent)		
Agricultural income	52.2	50.1	50.7	54.9	44.1
Crops and crop products	30.0 (100.0)	25.4 (100.0)	29.5 (100.0)	31.8 (100.0)	24.0 (100.0)
Farm wage	6.6 (70.0)	8.9 (77.0)	5.4 (60.0)	6.9 (72.0)	5.9 (68.0)
Livestock and livestock products	13.5 (95.0)	14.2 (90.0)	13.2 (96.0)	13.6 (96.0)	13.5 (91.0)
Nonagricultural income	29.4	35.3	28.2	30.4	26.6
Collected products	14.5 (97.0)	21.4 (96.0)	11.4 (98.0)	13.9 (99.0)	16.4 (91.0)
Handicrafts	2.6 (66.0)	4.6 (75.0)	2.1 (54.0)	2.4 (62.0)	3.5 (77.0)
Trading	4.9 (17.0)	1.1 (6.0)	7.6 (33.0)	5.8 (17.0)	2.3 (17.0)
Nonfarm wage	3.5 (18.0)	3.7 (17.0)	2.6 (17.0)	4.6 (25.0)	0.3 (2.0)
Transfers[a]	18.4 (68.0)	14.6 (63.0)	21.1 (85.0)	14.7 (59.0)	29.3 (91.0)
Remittances	8.5 (50.0)	4.3 (48.0)	11.8 (65.0)	7.0 (43.0)	13.1 (66.0)
Annual income per capita (SD£)	1,100	500	1,866	1,169	942

Source: International Food Policy Research Institute survey, 1989.
Note: Figures in parentheses refer to the percentage of participating families in the sample.
[a]Figures for transfers include remittances.

low agricultural income largely through transfers. Handicrafts are a minor but essential compensatory income source.

A considerable substitution between income sources was also evident in 1984-85 (Table 18). When farmers faced failure in their crop income, they resorted to sale of assets, collected products (grass, firewood, and so forth), and nonagricultural income. A sizable fraction of the sample derived their income primarily from liquidation of assets and nonagricultural sources (handicrafts and wage labor). Receipts in the form of loans and transfers also enhanced their income. Those in a better wealth position sold a large part of their assets (livestock and other household valuables). The asset-poor had to depend greatly on handicrafts and transfers to augment their low income from sale of assets.

The observed income response of the sample households is that when a large share of income is derived from crop-based activities (including wage income), all households share a greater risk of income failure. The current protective income sources (income from sale of collected products and transfers) are easily reversible

Table 18—Distribution of households by source of income, Kordofan survey villages, 1984-85

Income Source	Whole Sample	Wealth Group[a] Low	Wealth Group[a] High
	(percent of households)		
Sale of assets			
Livestock	62	55	66
Durables	32	17	45
Handicrafts	20	36	11
Wage labor	28	38	23
Loans	17	24	15
Transfers	26	36	21

Source: International Food Policy Research Institute survey, 1989.
[a]Bottom and top terciles of distribution of livestock ownership in 1984-85

and nonsustainable, particularly when viewed in terms of their implications for the environment. Furthermore, it is evident that the burden of coping is unequal and falls heavily on those who depend largely on crop-based income and have few protective income sources or assets. Households from the drier areas, especially asset-poor households headed by women and those headed by the old without working members, are at high risk.

To capture these factors that contribute to interhousehold income variations, income determination equations were estimated relating per capita household income to asset ownership, family labor, age of household head, sex of household head, education of household head (binary variable for having formal education or not), income source, and relative village effects in 1988/89. Estimates of variants of the income model are in Table 19. Variant 1 explains per capita earned income. Variants 2 and 3 are related to total income. Although transfer income may be considered as exogenous to household decisionmaking, its large share may pose a simultaneous bias problem. An alternate specification that was estimated without share income is thus included in the table.

The results confirm key hypothesized relations: the wealth and size of the labor force have major influences on household income; there is a gender bias in income variations—female-headed households earn much lower income than male-headed households; the education of the household head has an income effect; transfer income is important, especially as a substitute for earned income; and villages in the drier areas of the sample have much lower income per capita.

Consumption Response. The major diet component in the survey areas is millet-based porridge (*asida*) served with sauce or milk. At times, bread from sorghum (*kisra*) is served with a mild, spiced stew. An average family serves at least two meals per day, usually in the late morning and late afternoon. A light meal may be served in the evening. Hot tea is frequently served during the day, particularly after meals.

The key food ingredients that contribute to this diet are millet (cereal), cowpeas (legume), okra (vegetable), meat and milk (livestock products), sugar, tea,

Table 19—Determinants of household income, Kordofan survey villages, 1988/89

Explanatory Variable	(Variant 1) Earned Income Parameter Estimate	(Variant 2) Total Income Parameter Estimate	(Variant 3) Total Income Parameter Estimate
Adult-to-family ratio	478.52	560.77	665.43
	(2.96)	(2.79)	(3.22)*
Age of head of household (years)	29.29	18.64	3.54
	(1.62)	(0.83)	(0.15)
Age of head of household squared (years)	-0.26	-0.15	-0.01
	(-1.54)	(-0.71)	(-0.04)
Education of head of household (1 if formal education, 0 otherwise)	278.99	358.67	293.28
	(2.15)*	(2.22)*	(1.75)
Sex of head of household (1 if female, 0 otherwise)	-365.87	-535.03	-321.38
	(-3.36)*	(-3.95)*	(-2.55)*
Livestock per capita (LSU)[a]	624.82	800.31	922.05
	(5.40)*	(5.55)*	(6.33)*
Village dummy (1 if village from drier area, 0 otherwise)	-440.49	-574.00	-493.08
	(-3.79)*	(-3.97)*	(-3.32)*
Share of transfer income	-674.97	975.08	...
	(-3.01)*	(2.22)*	
Constant	-73.36	28.31	428.68
	(-0.16)	(0.05)	(0.79)
F	11.93	12.30	11.36
$\bar{R}^2$	0.38	0.39	0.34
N	141	141	141

Note: Figures in parentheses are t-statistics.
[a]LSU = livestock unit.
*Significant at the 99 percent confidence level.

and oil (Table 20). The participation is weakly income variant, except for meat and milk, which appear to rise with income level.

The consumption pattern observed in 1989 differs markedly from that practiced during 1985. Families had to cut the frequency as well as the size of meals to ration their food consumption in 1985 (Table 21).[3] About 70 percent of the sample households reported that they had to cut their meal size. One out of three survived

[3]A survey conducted in September 1984 in three districts of Northern Kordofan (Hamid et al., n.d.) shows that 40 percent of the sample had one or fewer meals during the survey period, compared with 2 percent a year earlier. Nineteen percent of the children had one milk serving a day before the survey, compared with 44 percent a year ago.

Table 20—Monthly expenditure per capita for frequently consumed food items, Kordofan survey villages, 1989

Food Item	Whole Sample	Expenditure Tercile		
		Low	Medium	High
		(SD£)		
Sorghum	3.60 (25)	3.64 (27)	3.82 (31)	3.31 (17)
Millet	16.42 (86)	14.06 (81)	16.66 (88)	18.55 (88)
Cowpeas	3.59 (83)	2.76 (79)	3.57 (86)	4.43 (85)
Okra	8.35 (99)	5.27 (98)	8.85 (100)	10.91 (100)
Meat (beef)	10.99 (59)	5.00 (46)	9.14 (55)	18.88 (77)
Meat (goat)	6.69 (43)	3.58 (35)	6.55 (49)	9.93 (46)
Milk (goat)	8.51 (73)	5.54 (65)	8.34 (71)	11.67 (83)
Sesame oil	8.05 (92)	5.72 (83)	8.84 (96)	9.57 (96)
Sugar	21.42 (99)	14.25 (98)	24.88 (100)	25.07 (100)
Tea	4.29 (98)	3.33 (98)	3.54 (100)	6.01 (96)

Source: International Food Policy Research Institute survey, 1989.
Note: Figures in parentheses are percentages of consuming households in the sample.

Table 21—Consumption responses of sample households, Kordofan survey villages, 1985

Response	Whole Sample	Wealth Group[a]	
		Low	High
		(percent of households)	
Meals per day			
One	34	43	26
Two	38	36	41
Three	28	21	31
Reduced quantities	70	81	64
Collected food	29	21	38
Consumed foods normally not eaten	17	14	19

Source: International Food Policy Research Institute survey, 1989.
[a]Bottom and top terciles of distribution of livestock ownership in 1984-85.

on a single meal. Approximately a quarter of the sample subsisted on a reduced single meal. A greater percentage of these households were from the low-asset group.

The composition of diets shifted largely to sorghum, wheat flour, meats, and wild cereals and tree fruits (wild rice, *kursan*, *nebag*, and *aradabe*). Twenty-seven percent of the sample resorted to consumption of wild rice and tree fruits. Fifty-nine percent of these indicated that they would not have consumed these food items in a normal year. Variation in consumption of these items was largely location-specific. Consumption was much lower in the drier areas, where such plants are less able to grow.[4]

Millet, the main staple in the area, which is usually drawn from own stocks for consumption, was not available in rural markets. Hence the rural population had to depend greatly on the market to obtain its foods. Sorghum and wheat flour were obtained largely from the market. Meats were obtained from own stock as well as the market. Wild rice and tree fruits were partly collected and partly purchased (wild rice—a misleading term, suggests availability at no cost).

[4]An OXFAM-UNICEF-Kordofan Government study (1985b) shows considerable district variation in the percentage of households that consumed these foods: 79 percent in En Nahud, 63 percent in El Obeid, and 33 percent in Sodari. The availability of such foods diminished northward—particularly in the drier areas, where drought was intense.

4

DROUGHT-PRODUCTION RELATIONSHIPS

The central thrust of this chapter is to establish a quantitative measure between drought and production in the drought-famine chain (Figure 3). As a background, the structure and development of Sudan's agriculture are discussed with emphasis on the performance of cereal production. Trends in rainfall patterns are described, and a model relating rainfall to production is then estimated at country and regional levels, disaggregated by major crops.

Development of Agricultural Production

Agriculture accounted for 48 percent of the gross domestic product (GDP) in 1965. Its relative contribution declined to 39 percent in the 1974-78 period. In the 1980s, its share oscillated between 31 and 38 percent, with the lowest share occurring in 1984 and 1987—the years notable for the lowest rainfall levels (Table 22).

Value added from crop production constitutes the principal source of GDP in agriculture. The crop subsector contributed nearly 60 percent of the sector's value added in the 1981-87 period. Within the subsector, the irrigated crops maintained a relatively stable and large share (60 percent) in the 1980s. Their relative contribution was high in 1984 and 1987 because of a large drop in production of rainfed crops.

The principal crops are cotton, sorghum, millet, wheat, sesame, and groundnuts. Cotton and wheat are irrigated crops grown mainly in the Gezira scheme in Central Region. Cotton is the prime foreign exchange earner, while wheat is an import substitute for the growing urban-based demand. Sorghum is the main staple

Table 22—Relative shares of agricultural components of gross domestic product, Sudan, 1981-87

GDP Component	1981	1982	1983	1984	1985	1986	1987	Average, 1981-87
Agricultural GDP	0.38	0.35	0.35	0.31	0.36	0.35	0.31	0.35
Crops	0.59	0.55	0.55	0.57	0.62	0.58	0.52	0.57
Irrigated	0.41	0.60	0.63	0.75	0.56	0.55	0.67	0.60
Rainfed	0.59	0.40	0.37	0.25	0.44	0.44	0.32	0.40
Mechanized	0.25	0.14	0.14	0.07	0.21	0.24	0.12	0.17
Traditional	0.34	0.26	0.23	0.18	0.23	0.20	0.20	0.23
Livestock	0.33	0.36	0.36	0.32	0.29	0.33	0.38	0.34
Forestry and fishery	0.08	0.09	0.09	0.11	0.09	0.09	0.10	0.09

Source: Based on data files of the Ministry of Finance and Economic Planning, Khartoum.

crop throughout Sudan except in the provinces of Northern Darfur and Northern Kordofan. Even though it is emerging as an important crop in the irrigated schemes, it is mainly grown in rainfed areas under mechanized technology (Table 23). Production is largely concentrated in the central plain that covers Eastern and Central regions, Southern Darfur, and Southern Kordofan (Table 24). Millet and sesame are rainfed crops. Millet, an important staple in the west, is nonmechanized and grows mainly in Darfur and Kordofan (Table 23). Sesame is partly mechanized

Table 23—Shares of crop production in Sudan, by technology type, 1961-86

Crop	Period	Irrigated	Rainfed	
			Mechanized	Traditional
			(percent)	
Cereals				
Sorghum	1961-66	20.9	17.0	62.1
	1974-81	10.7	55.1	34.3
	1982-86	18.3	63.0	18.7
Millet	1961-86	1.2	...	98.8
Wheat	1961-86	100.0	...	...
Oilseeds				
Sesame	1961-66	...	8.7	91.3
	1974-81	...	29.7	70.3
	1982-86	...	49.1	51.0
Groundnuts	1961-66	23.4	...	76.6
	1974-81	39.2	...	60.8
	1982-86	46.4	...	53.6
Cotton	1961-66	91.6	8.4	...
	1974-81	95.8	4.2	...
	1982-86	96.0	4.0	...

Source: Sudan, Ministry of Agriculture and Natural Resources, *Yearbook of Agricultural Statistics* (Khartoum: MANR, 1970, 1984, and 1987).

Table 24—Average production shares of food crops, by main producing provinces, 1974-86

Crop	Province	Region	Production Share
			(percent)
Sorghum	Kassala	Eastern	32.1
	Gezira	Central	10.2
	Blue Nile	Central	22.9
	Southern Kordofan	Kordofan	8.8
Millet	Northern Kordofan	Kordofan	32.2
	Northern Darfur	Darfur	17.4
	Southern Darfur	Darfur	39.6
Wheat	Gezira	Central	73.0

Source: Based on data files of the Ministry of Agriculture and Natural Resources, Department of Agricultural Economics, Statistics Section, Khartoum.

and production is spread among Darfur, Kordofan, Central, and Eastern regions. Groundnuts are grown in both irrigated and nonmechanized rainfed areas, but there is a growing shift to irrigated areas, partly in response to low profitability in the western regions, where rainfall is low and highly variable.

Livestock remains an important subsector, with a contribution of one-third of agricultural GDP. Lack of consensus on growth estimates makes it difficult to determine the actual livestock population in the country. The official estimates for 1985 reported 22.1 million head of cattle, 19.3 million sheep, 14.6 million goats, and 2.8 million camels. Most of these stocks are concentrated in Central, Darfur, and Kordofan regions. They are particularly important sources of employment and livelihood for the nomadic population. Lower growth rates in the early 1980s reflected the effects of 1980 droughts, which were characterized by high mortality accompanied by lower birth rates, especially in the western regions (Table 25).

The crop and livestock components are the main influences on the agricultural sector's relative performance. The agricultural GDP, for example, experienced a record per capita fall of 26.4 percent in 1984 relative to the 1983 crop year—assuming a 2.9 percent annual growth in population. There was a recovery in the 1985 season, but this was reversed in 1987. The performance of these components was largely precipitated by continuous failures of rainfed crops and, as in the case of the 1984 season, by large losses of livestock (Table 26).

Cereal Production Performance

Sorghum

Production of sorghum increased from an average of 1.3 million metric tons[5] in the 1961-73 period to 2.2 million tons in the 1974-86 period (Table 27). Area under sorghum increased from 3.9 million feddans to 8.1 million feddans over the same

Table 25—Estimated livestock population in Sudan, 1981-85, and growth rates, 1976-85

	Number			Growth Rates	
Species	1981	1983	1985	1976-80	1981-85
		(million)		(percent)	
Cattle	20.0	21.0	22.1	6.1	2.6
Sheep	18.6	20.0	19.3	2.8	3.3[a]
Goats	13.8	14.1	14.6	4.1	2.0
Camels	2.8	2.8	2.8	3.4	1.2

Source: Information from the Ministry of Agriculture and Natural Resources, Animal Resources Economics Administration (these rates were applied to estimate livestock population for the period 1976-80, and FAO growth-rate estimates were applied for the 1981-85 period).

[a]The growth rate shown here is contrary to the observations in the 1989 International Food Policy Research Institute survey of Northern Kordofan villages, which showed a decreasing rate for the 1981-85 period.

[5]All tons in this report are metric tons.

Table 26—Growth rates of agricultural components of gross domestic product, Sudan, 1982-87

GDP Component	1982	1983	1984	1985	1986	1987
			(percent change from previous year)			
Agricultural GDP	-7.6	-2.3	-23.5	30.4	2.0	-12.1
Crops	-13.4	-2.6	-21.0	40.6	-3.4	-21.4
Irrigated	26.7	3.1	-6.0	4.9	-4.9	-3.9
Rainfed						
Mechanized	-51.1	1.2	-63.4	345.3	11.2	-59.9
Traditional	-33.6	-17.4	-36.8	75.3	-13.1	-22.3
Livestock	1.0	-4.3	-32.7	19.7	12.8	1.5

Source: Based on data files of the Ministry of Finance and Economic Planning, Khartoum.

periods. Area growth averaged an annual rate of 5.3 percent (Table 28). Average yield, on the other hand, experienced a steady decline from 348 kilograms to 273 kilograms per feddan over the 26-year period at an annual rate of -2.1 percent.

Production growth peaked in 1974-86 at a drought-excluding growth rate of 4.6 percent (Table 28). This occurred mainly as a result of a 6.3 percent growth in cultivated area. Rapid expansion of mechanized farms, particularly in Central and Eastern regions, contributed largely to the record growth. Production from these farms grew at an annual rate of 7.7 percent, mainly due to 8.9 percent growth in area (Table 29).

Growth was much lower when the effect of the 1984 drought was included in the growth estimate. The growth rate for mechanized sorghum production dropped

Table 27—Average production, area, and yield of cereal crops in Sudan, 1961-86

Crop	1961-73		1974-86	
Sorghum				
Production (1,000 metric tons)	1,349	(307)	2,183	(719)
Area (1,000 feddans)	3,885	(791)	8,059	(2,196)
Yield (kilograms/feddan)	348	(43)	273	(55)
Millet				
Production (1,000 metric tons)	328	(72)	394	(106)
Area (1,000 feddans)	1,606	(529)	2,969	(462)
Yield (kilograms/feddan)	218	(52)	136	(40)
Wheat				
Production (1,000 metric tons)	100	(58)	203	(66)
Area (1,000 feddans)	201	(110)	440	(162)
Yield (kilograms/feddan)	520	(103)	484	(91)

Source: Based on data files of the Ministry of Agriculture and Natural Resources, Department of Agricultural Economics, Statistics Section, Khartoum.

Note: Figures in parentheses are standard deviations of means.

Table 28—Growth rates of production, area, and yield of cereal crops in Sudan, 1961-86

Crop	1961-73	1974-86	1961-86
		(percent)	
Sorghum			
Production	1.8[a]	2.6 (4.6)	3.2 (3.8)
Area	3.4	5.7 (6.3)	5.3 (5.4)
Yield	-1.7	-3.1 (-1.7)	-2.1 (-1.6)
Millet			
Production	2.9	-4.2 (-2.3)	0.8 (1.5)
Area	7.9	2.7 (2.8)	5.1 (5.2)
Yield	-5.0	-6.8 (-5.1)	-4.3 (-3.7)
Wheat			
Production	16.4	-6.9 (-5.3)	6.0 (6.9)
Area	17.8	-9.7 (-7.4)	6.2 (7.4)
Yield	-1.4[b]	2.8 (b)	-0.2 (b)

Source: Based on data files of the Ministry of Agriculture and Natural Resources, Department of Agricultural Economics, Statistics Section, Khartoum.

Note: Figures in parentheses are drought-free, that is, they exclude the 1984/85 season.

[a]t-values are statistically significant for corresponding growth rates (parameter estimates are at least two times the associated standard error).

[b]Growth rates are not reported for lack of acceptable statistical significance.

to 4.4 percent due to a substantial drop in the rate of yield growth (Table 29). For the nonmechanized areas, the 1984/85 season exacerbated the shortfalls in yield. The only exception was the irrigated sector, which experienced positive growth but, because of its small share, had a marginal impact on overall performance. The overall effect of 1984/85 was a sluggish growth in sorghum production, largely

Table 29—Growth rates of sorghum production, area, and yield in Sudan, by technology, 1961-86

Technology	1961-73	1974-86		1961-86	
		(percent)			
Traditional (rainfed)					
Production	-3.1	-5.5	(-4.1)	-2.2	(-1.6)
Area	-0.01	1.5	(1.7)	1.5	(1.5)
Yield	-2.3	-7.0	(-5.9)	-3.6	(-3.2)
Mechanized (rainfed)					
Production	11.7	4.4	(7.7)	9.6	(10.7)
Area	13.8	8.1	(8.9)	11.5	(11.8)
Yield	-2.1	-3.7	(-1.2)	-1.9	(-1.1)
Irrigated					
Production	1.1	8.0	(7.6)	1.8	(1.6)
Area	1.8	5.7	(5.7)	2.1	(2.0)
Yield	-0.7	2.2	(1.8)	-0.3	(-0.5)

Source: Based on data files of the Ministry of Agriculture and Natural Resources, Department of Agricultural Economics, Statistics Section, Khartoum.

Note: Figures in parentheses are drought-free, that is, they exclude the 1984/85 season.

attributed to the sharp drop in yield. There were sizable variations in growth performance among the important production regions (Table 30). Regions with better access to water—whether from rain or irrigation—demonstrated a lower drop in yield growth.

Variation in production levels across the subperiods was associated with increased instability. Fluctuations were more pronounced in the 1982-86 period. This is illustrated by comparisons of indices in Table 31. Relative to the normal years of

Table 30—Average growth rates of production, area, and yield of food crops, by main producing provinces, 1974-86

Crop/Province	Region	Production	Area	Yield
			(percent)	
Sorghum				
Kassala	Eastern	3.4	6.1	-2.6
Gezira	Central	2.8	3.4	-0.6
Blue Nile	Central	7.1	8.9	-1.7
Southern Kordofan	Kordofan	a	6.3	-5.8
Millet				
Northern Kordofan	Kordofan	-6.4	1.3	-7.8
Northern Darfur	Darfur	-5.1	1.1	-6.2
Southern Darfur	Darfur	a	6.2	-7.6
Wheat				
Gezira	Central	-17.8	-19.5	a

Source: Based on data files of the Ministry of Agriculture and Natural Resources, Department of Agricultural Economics, Statistics Section, Khartoum.
Note: Growth estimates include the 1984/85 season.
[a]Growth rates not reported for lack of statistical significance.

Table 31—Indices of production, area, and yield of cereal crops in Sudan, 1974-86

Crop	1974-78	1980-81	1982-83	1984	1985	1986
Sorghum						
Production	100	134	94	55	180	164
Area	100	123	133	121	200	180
Yield	100	107	71	45	90	91
Millet						
Production	100	120	78	38	102	68
Area	100	98	103	111	146	131
Yield	100	185	113	51	104	78
Wheat						
Production	100	69	60	30	77	60
Area	100	62	53	19	58	46
Yield	100	110	111	163	131	132

Source: Based on data files of the Ministry of Agriculture and Natural Resources, Department of Agricultural Economics, Statistics Section, Khartoum.
Note: Mean levels of production, area, and yield for the three crops in 1974-78 are sorghum—2.0 million metric tons, 6.6 million feddans, 304 kilograms per feddan; millet—418,000 metric tons, 2.8 million feddans, 146 kilograms per feddan; wheat—260,000 metric tons, 616,200 feddans, 421 kilograms per feddan.

1974-78, production of sorghum increased in 1980 and 1981, dropped for the next three years, and recovered strongly in 1985. Fluctuations in production mainly reflect variability in yield.

Millet

Average annual production of millet increased from 328,000 tons in 1961-73 to 394,000 tons in 1974-86 (Table 27). For the whole 26-year period, no significant production trend was established (Table 28). However, the area under millet increased continuously, from 1.6 million feddans in 1961-73 to 3.0 million feddans in 1974-86, at an average annual growth rate of 5.1 percent. Average yields dropped over the same periods from 218 kilograms to 136 kilograms per feddan at a growth rate of −4.3 percent.

The low-growth production path of millet was largely determined by the drought years of the 1980s. Production showed an average growth rate of −4.2 percent in the 1974-86 period. The growth rate improves by 1.9 percent when the 1984/85 season is excluded (Table 28). Area planted grew at a rate of 2.7 percent, but yield recorded a growth of −6.8 percent. Thus, despite an increase in area planted to millet, yield decline overwhelmed the production trend. A large-scale decline in production and yield occurred in the main production areas of Northern Kordofan and Northern Darfur (Table 30).

Production of millet is marked by considerable and increasing year-to-year variations. The greatest source of instability is related to yield variability. The instability measure in Table 32 shows a 3-to-1 ratio between yield and area coefficients.

Wheat

Production of wheat is concentrated in the irrigated schemes, particularly in Gezira. Like that of other irrigated crops, the annual production is governed by an

Table 32—Relative variability in cereal crop production, area, and yield in Sudan, 1961-86

Crop	1961-73	1974-81	1982-86	1961-86
		(coefficients of variation)		
Sorghum				
Production	22.8	25.9	38.6	30.2
Area	15.8	14.1	17.3	15.4
Yield	11.1	10.3	25.6	14.9
Millet				
Production	20.2	27.8	32.2	28.8
Area	14.5	9.6	10.0	15.1
Yield	18.6	18.9	30.6	25.4
Wheat				
Production	14.4	19.1	29.9	41.5
Area	21.4	11.3	35.0	47.5
Yield	19.9	17.8	15.6	19.1

Source: Based on data files of the Ministry of Agriculture and Natural Resources, Department of Agricultural Economics, Statistics Section, Khartoum.

Note: Computations are based on a general measure of instability developed by Cuddy and Valle (1978).

administrative set of rules on area allocation, water use, and prices. Wheat is grown in winter (*rabi* season) as part of a regular crop-rotation cycle. It usually follows the summer crops of sorghum and groundnuts. The availability of water in the winter months and relative allocation between competing crops, cotton in particular, determine much of its production performance.

Compared with the 1961-73 period, production as well as area reached higher mean levels during 1974-86 (Table 27). Production grew from 100,000 tons to 203,000 tons. Area increased from 201,000 feddans to 440,000 feddans. Average productivity, on the other hand, fell from 520 to 484 kilograms per feddan.

Wheat yield, unlike the yield of rainfed crops, registered positive growth, but not enough to overwhelm the depressing effect of area contraction (Table 28). In fact, area under wheat decreased continuously from 1976 to 1982, recovered in 1983 due to the addition of new areas, but dropped to a record low in 1984. Production of wheat was banned in the Gezira scheme in 1984 because of the low water level of the Blue Nile, which feeds two-thirds of the irrigated areas.

Records of growth patterns and performance among the three cereal crops show some notable experiences (Tables 27-32). First, production growth has been largely based on expansion of area. In the case of sorghum, this expansion has been accompanied by rapid mechanization. For wheat, area contraction was the main factor for poor performance in the 1974-86 period. Second, the contribution of productivity to growth of production has been minimal. In fact, production growth for most crops has occurred in an environment of declining productivity, particularly for those crops that are grown in the nonmechanized rainfed system. Occurrences of droughts exacerbate the poor yield base of these crops. Finally, production levels are associated with high relative variances. Sources of fluctuation appear to be climate-based for rainfed crops, such as sorghum and millet, and policy-induced in the case of wheat.

Rainfall Patterns in the Main Production Areas

Recorded rainfall data for 1960-86 covering selected areas located between 10° 00′ and 14° 20′ north latitudes and between 24° 20′ and 35° 24′ east longitudes are examined in this section. The sampled areas cut across the regions of Darfur (El Fasher and Nyala) and Kordofan (En Nahud and Kadugli), and the Central (Kosti, Sennar, and Roseries) and Eastern (Gedaref) regions (Table 33). Kadugli, Kosti, Sennar, Roseries, and Gedaref are important sorghum-production areas. Millet is an important crop in the west, particularly in Darfur and Northern Kordofan Province.

Mean total precipitation increases southward, and for localities on the same latitude, rainfall tends to increase eastward. Similar patterns are observed for the number of rainy days (Table 33). For most of the sample stations, the mean levels for both total precipitation and number of rainy days show a declining pattern over the 27-year period. The 10-year mean of annual precipitation in the 1970s was below the 10-year mean of the 1960s in six of the eight sampled sites. The mean levels of the early 1980s were far below those of the 1960s in all the sites. There were also fewer rainy days in the 1970s and even fewer in the early 1980s as compared with the 1960s (Table 34). The decline in rainfall totals appears to be

Table 33—Mean rainfall and rainy days at selected stations, 1960-86

Region/Site	Province	Latitude	Longitude	Mean Rainfall	Coefficient of Variation	Mean Rainy Days
				(millimeters)		
Central						
Sennar	Blue Nile	13°33'N	33°37'E	427.0	0.27	34.6
Kosti	White Nile	13°02'N	32°40'E	355.6	0.24	41.3
Roseries	Blue Nile	11°51'N	34°24'E	646.9	0.14	46.7
Darfur						
El Fasher	Northern Darfur	13°38'N	25°20'E	220.9	0.29	29.0
Nyala	Southern Darfur	12°04'N	24°53'E	417.3	0.20	38.6
Eastern						
Gedaref	Kassala	14°02'N	35°24'E	595.9	0.17	54.2
Kordofan						
En Nahud	Northern Kordofan	12°40'N	28°26'E	352.3	0.27	39.2
Kadugli	Southern Kordofan	10°00'N	29°43'E	681.8	0.20	61.4

Source: Computed from raw data from the Sudan Meteorological Department, Khartoum.

associated with fewer rainy days. Such a pattern could contribute to the greater propensity for drought to occur in areas where soils have low water-holding capacity.

The annual distribution of rainfall shows that most of the rains occur in the months between June and September. The months of July and August represent the peak months and account for a large share of total precipitation. Ibrahim's (1984) findings on Northern Darfur also reveal that annual precipitation curves are steeper toward the north, that is, precipitation tends to be concentrated heavily in the wet months, particularly in August.

Temporal variations in total precipitation are notable among the sample sites. The coefficients of variation around estimated trends vary between 0.29 in El Fasher and 0.14 in Roseries (Table 33). El Fasher (0.29), En Nahud (0.27), and Kosti (0.24) show relatively high variability. El-Tom's (1986) findings also confirm considerable rainfall fluctuation in Khartoum, El Fasher, and El Obeid. Relative variation is more prominent in the arid and semi-arid climatic zones, especially in the west.

The year-to-year fluctuations in rainfall increased considerably in the 1980s as compared with earlier decades within these sample areas. The coefficients of variation increased from a low of 0.13 in the 1960s to 0.33 in the 1970s and 0.34 in the 1980s in El Fasher. In En Nahud, it progressed from 0.18 to 0.23 and 0.45 in the three decades, respectively. A similar pattern was observed in Kosti (0.18 in the 1960s, 0.17 in the 1970s, and 0.32 in the 1980s), Nyala (0.18 in the 1960s, 0.16 in the 1970s, and 0.29 in the 1980s), and Roseries (0.11 in the 1960s to 0.17 in the 1970s and 0.18 in the 1980s). The 1980s were definitely marked by large fluctuations that were largely reflective of variations in the number of rainy days.

There are important issues of interest that are not evident in the studies discussed above. First, is the shift in the climatic pattern part of a cyclical phenomenon? Second, how are low rainfall levels compatible with growth of food crops (by

Table 34—Distribution of mean rainfall, rainy days, and rain per day at selected stations, 1960-86

Region/Site	Mean Annual Rainfall			Mean Rainy Days			Mean Rain per Day		
	1960-69	1970-79	1980-86	1960-69	1970-79	1980-85	1960-69	1970-79	1980-86
	(millimeters)						(millimeters)		
Central									
Sennar	461.7	446.2	315.0	37.9	32.3	32.0	12.2	13.8	9.8
Kosti	372.8	391.4	273.0	47.7	41.4	31.0	7.8	9.5	8.8
Roseries	727.6	665.5	504.9	59.9	44.6	29.4	12.1	14.9	17.2
Darfur									
El Fasher	271.9	203.0	168.6	38.9	26.4	18.6	7.0	7.7	9.1
Nyala	470.1	414.4	367.5	42.8	38.7	33.2	11.0	10.6	11.1
Eastern									
Gedaref	579.1	623.2	543.5	49.7	59.7	50.6	11.7	10.4	10.7
Kordofan									
En Nahud	373.0	349.7	337.9	44.6	37.6	32.8	8.4	9.3	10.3
Kadugli	748.0	673.5	584.3	58.7	67.4	56.8	12.7	10.0	10.3

Source: Computed from raw data from the Sudan Meteorological Department, Khartoum.

type and variety) across the country's production zones? Finally, to what extent does the spread of annual rainfall match the optimal growth cycle of crops? These questions may be relevant in the context of the search for technological innovation and commodity priorities in the drought-prone regions.

Drought-Production Relationships

The preceding discussion on the performance of cereal crop production in the 1980s highlights the adverse effects of drought on growth components, particularly yields. The effect of drought on cereal production is largely mediated through the short-run impact on yield. In this section, an attempt is made to isolate the systematic impact of rainfall through simple supply functions defined as

$$Q_{it} = \alpha_0 + \alpha_1\, RAIN_t + \alpha_2\, (RAIN_t)^2 + \alpha_3\, P_{it-1} + \alpha_4\, P_{jt-1} + \alpha_5\, T + u_t, \qquad (4)$$

where

Q_{it} = production or yield of crop i in period t,
$RAIN_t$ = rainfall index in period t,
P_{it-1} = own deflated price in period t−1,
P_{jt-1} = price of competing crop j in period t−1,
T = time trend,
u_t = random error term in period t, and
α_0, α_1, α_2, α_3, α_4, and α_5 are parameters to be estimated.

Total annual rainfall for selected sites weighted by respective production shares was used for aggregate cereals and sorghum. In the case of millet, however, the relevant measure was total rainfall in the months of June, July, and August. Weights were derived from production records of the 1974-86 period. Prices are weighted regional wholesale prices. The gross national product (GNP) deflator was used to deflate the prices. Price terms were dropped from yield equations due to poor response. No price terms were included in millet equations due to lack of complete series. All the variables were in natural logarithms. The choice of the functional form was based on a preliminary evaluation of the values of the log-likelihood function and the correlation coefficients between predicted and observed values of the dependent variables for alternative functional forms.

The rainfall effect on production as well as yield is hypothesized to be positive but to diminish at the margin. The square term of rainfall in the supply equation is expected to take a negative sign. The time trend is used as a proxy for technology, especially mechanization, and increased labor use.

Table 35 presents the parameter estimates and associated t-statistics. The coefficients for the rainfall term are significant (t-ratios equal to or greater than 2.0) in 13 out of 17 cases. Rainfall has a significant systematic impact on production responses. The squared terms are also significant, and the signs suggest that rainfall does affect production but at a diminishing rate. The trend variable has a significant impact on yields for all-Sudan cereals, sorghum, and millet. Since adding price could not diminish the effect of the trend variable, factors other than rainfall and

Table 35—Parameter estimates of yield and production response equations for cereal crops

Cereal	Region	Period	Dependent Variable[a]	Independent Variables					Constant	Log LF[b]	Degrees of Freedom
				$RAIN_t$	$RAINSQ_t$	$TREND_t$	$OPRC_{t-1}$	$CPRC_{t-1}$			
Cereals[c]	Sudan	1969-76	CRYLD	13.63	-1.10	-0.02	...	...	-4.93	-82.94	14
				(2.48)	(-2.32)	(-2.85)			(-0.26)		
			CRPRD	16.14	-1.30	0.04	...	...	-116.41	-131.86	14
				(1.82)	(-1.70)	(4.11)			(-3.80)		
Sorghum	Sudan	1969-86	SSRYD	17.59	-1.41	-0.02	...	...	-19.20	-81.79	13
				(2.16)	(-2.05)	(-2.32)			(-0.70)		
			SSRPD	33.12	-2.71	...	0.52	-0.33	-83.85	-124.53	12
				(2.15)	(-2.07)		(3.26)	(-2.62)	(-2.07)		
			SSRPD	24.74	-1.99	0.05	...	...	-161.82	-123.40	13
				(1.82)	(-1.73)	(4.33)			(-3.53)		
	Eastern (Gedaref)	1973-86	GSRYD	28.85	-2.21	0.01	...	...	-88.44	-65.88	9
				(3.92)	(-3.38)	(0.21)			(-3.44)		
			GSRPD	42.92	-3.34	0.06	...	...	-136.23	-81.53	9
				(3.68)	(-3.58)	(2.93)			(-3.72)		
			GSRPD	45.15	-3.53	...	0.33	-0.21	-137.93	-82.68	8
				(3.93)	(-3.84)		(1.35)	(-1.10)	(-3.86)		
	Central (Blue Nile)	1973-86	BNSYD	16.02	-1.18	0.03	...	...	-51.05	-66.74	8
				(2.34)	(-2.18)	(1.54)			(-2.38)		
			BNSPD	21.83	-1.16	0.15	...	...	-79.62	-80.74	9
				(1.65)	(-1.53)	(3.83)			(-1.91)		
			BNSPD	31.12	-2.38	...	0.75	-0.48	-95.79	-82.49	8
				(2.19)	(-2.12)		(2.12)	(-1.72)	(-2.13)		
Millet	Sudan	1969-86	SMLYD	10.61	-1.23	-0.05	...	...	-14.10	-86.86	14
				(3.08)	(-2.97)	(-2.11)			(-1.90)		
			SMLPD	12.56	-1.44	-0.002	...	...	-21.60	-104.96	14
				(2.80)	(-2.68)	(0.17)			(-2.26)		
	Kordofan (Northern)	1973-86	KMLYD	22.07	-2.02	-0.04	...	...	32.30	-64.71	10
				(2.98)	(-2.84)	(-1.65)			(0.56)		
			KMLPD	20.29	-1.85	-0.03	...	...	17.27	-68.93	10
				(2.44)	(-2.33)	(-1.42)			(0.32)		

(continued)

Table 35—Continued

Cereal	Region	Period	Dependent Variable[a]	Independent Variables: $RAIN_t$	$RAINSQ_t$	$TREND_t$	$OPRC_{t-1}$	$CPRC_{t-1}$	Constant	Log LF[b]	Degrees of Freedom
Millet	Darfur (Southern)	1973-76	DMLYD	9.78 (2.66)	−0.86 (−2.46)	−0.05 (−2.98)	...	...	85.94 (2.16)	−65.39	10
			DMLPD	4.68 (1.19)	−0.38 (−1.05)	0.004 (0.10)	...	...	−17.46 (−0.22)	−66.46	10

Source: Based on data files of the Ministry of Agriculture and Natural Resources, Department of Agricultural Economics, Statistics Section, Khartoum.
Note: Figures in parentheses are t-values.
[a]Coefficients are adjusted for autocorrelation of error terms using Cochrane-Orcutt procedure.
[b]Log LF is the value of the log-likelihood function at convergence.
[c]Cereals include sorghum and millet only.

Definitions of variables:

CRYLD = Sudan cereal yield per feddan in kilograms;
CRPRD = Sudan cereal production in 1,000 metric tons;
SSRYD = Sudan sorghum yield per feddan in kilograms;
SSRPD = Sudan sorghum production in 1,000 metric tons;
GSRYD = Gedaref sorghum yield per feddan in kilograms;
GSRPD = Gedaref sorghum production in 1,000 metric tons;
BNSYD = Blue Nile sorghum yield per feddan in kilograms;
BNSPD = Blue Nile sorghum production in 1,000 metric tons;
SMLYD = Sudan millet yield per feddan in kilograms;
SMLPD = Sudan millet production in 1,000 metric tons;
KMLYD = Northern Kordofan millet yield per feddan in kilograms;
KMLPD = Northern Kordofan millet production in 1,000 metric tons;
DMLYD = Southern Darfur millet yield per feddan in kilograms;
DMLPD = Southern Darfur millet production in 1,000 metric tons;
$RAIN_t$ = rainfall index in period t;
$RAINSQ_t$ = rainfall squared;
$OPRC_{t-1}$ = own price in period t−1; and
$CPRC_{t-1}$ = competing price in period t−1.

price should explain the observed trend. In the case of production response, however, the effect of trend diminishes when price variables are included.

The corresponding elasticities evaluated at sample means are given in Table 36. The elasticities measure the percentage change in production or yield for a 10 percent change in rainfall, adjusted for curvature effect. The results suggest that a 10.0 percent drop in annual rainfall results in a 5.0 percent and 7.3 percent drop in cereal and sorghum production, respectively. The corresponding drops in yield are 3.7 and 5.4 percent. The elasticities are smaller for aggregate millet: 1.6 percent for yield and 3.0 percent for production. Sorghum is more sensitive than millet to rainfall changes.

The elasticities also suggest that regional/provincial production is more sensitive to rainfall fluctuation than is aggregate production. Sorghum in Blue Nile Province, for example, shows a 10.4 percent drop in yield compared with 5.4 percent for aggregate sorghum, and a 15.2 percent drop in production compared with 7.3 percent for the aggregate. The greater response at the regional level also holds for millet; compare 5.3 percent for millet yield in Northern Kordofan to 1.6 percent for aggregate millet yield. There are also significant interregional differences in elasticities for the same crop.

The effects of price changes on sorghum production can be read directly from Table 35. A 10.0 percent increase in the price of sorghum results in a 5.2 percent increase in production. The increase is 7.5 percent in the Blue Nile Province. A rise in the relative price of sesame encourages farmers to move out from sorghum production; a 10.0 percent increase in the price of sesame leads to a 3.3 percent cut in aggregate sorghum production. The response is again greater in the Blue Nile area, where farmers cut sorghum production by 4.8 percent for a 10.0 percent increase in the relative price of sesame.

Table 36—Response of yield and production of rainfed cereal crops to a 10 percent change in rainfall index

Crop	Region	Response Variable	Rainfall Effect
			(percent)
Cereals	Sudan	Yield	3.7
		Production	5.0
Sorghum	Sudan	Yield	5.4
		Production	7.3
	Eastern	Yield	4.9
	(Gedaref)	Production	1.4
	Central	Yield	10.4
	(Blue Nile)	Production	15.2
Millet	Sudan	Yield	1.6
		Production	3.0
	Kordofan	Yield	5.3
	(Northern)	Production	5.6
	Darfur	Yield	3.2
	(Southern)	Production	5.0

Source: Calculated from the results in Table 26.

5

PRICES AND MARKET DISCONNECTIONS DURING FAMINES

It is of central importance for government policymakers to have a comprehensive understanding of the functioning of markets during food-shortage situations caused by domestic production decline. Understanding of the production-price relationship provides a key input into policies regarding interregional trade, stockholding, and imports (including food aid). The following assessment of market behavior during the past two decades pulls together some critical facts considered as inputs for informed decisionmaking related to such policies and government interventions.

The focus of this analysis will be on presenting factual information on price development and establishing factors that contribute to such behavior. The main components of price development are related to the evolution of absolute and relative price movements, seasonality of prices, and regional price spread. The shifts in relative prices between cereals and cash crops and between cereals and livestock are important indicators of the erosion of purchasing power during food-shortage situations. The pattern of seasonality of prices, which often follows local production patterns, may change during a period of drought, giving rise to different timing of sales and amplitude of price changes. The extent to which deviations from normal patterns occur indicates the potential complementary role of other sources of supply—imports, stocks, and food aid—in smoothing intrayear variations. Differences in interregional price variations hint at the key role of better market integration through improved rural infrastructure. The short-term effects of production and food availability declines on prices and terms of trade hint at the critical need for a very rapid mobilization of resources and programs to cope with the short-term food-security problem of the poor when drought hits.

Evolution of Food Prices

Price Levels

Cereal prices rose steadily in the early 1980s, peaked in 1984, and then dropped in the 1985 and 1986 seasons (Table 37). Between 1982/83 and 1984, cereal prices increased threefold. The real price in the 1985/86 season was at the level prevailing in the 1970s (Figure 8).

A rapid price increase occurred in the months preceding the harvest season of 1984. The nominal price of sorghum in the El Obeid market in the west, for example, increased from SD£32 to SD£57 and then to SD£137 per 100 kilograms in the months of January, July, and October 1984, respectively (Table 38). The price was nearly five times higher in October 1984 than in the same month in 1983.

Table 37—Undeflated average wholesale prices for crops and cattle in selected markets, 1974-86

Period	All-Sudan Cereals[a]	Sorghum		Millet		Sesame	Cattle	
		Gedaref	El Obeid	Nyala	El Obeid	El Obeid	Nyala	El Obeid
		(SD£/100 kilograms)					(SD£/head)	
1974-78	3.71	2.94	5.07	6.71	n.a.	12.36	36.78	40.16
1980-81	14.04	9.66	18.85	36.79	n.a.	35.11	161.21	172.92
1982-83	35.81	29.21	36.34	71.23	51.17	87.50	277.71	272.00
1984	117.79	98.58	108.63	217.13	141.18	157.80	187.71	204.50
1985	57.53	53.50	80.00	88.70	66.77	189.09	672.33	645.67
1986	31.97	28.35	39.78	71.85	60.33	172.98	1,504.00	1,326.50

Sources: Sudan, Ministry of Agriculture and Natural Resources, *Agricultural Prices in Sudan: A Historical Review and Analysis, 1970-1984* (Khartoum: MANR, 1985); MANR, *Agricultural Situation and Outlook: 1986-1987* (Khartoum: MANR, 1987); and MANR, *Current Agricultural Statistics: 1984/85 and 1985/86* (Khartoum: MANR, 1988).

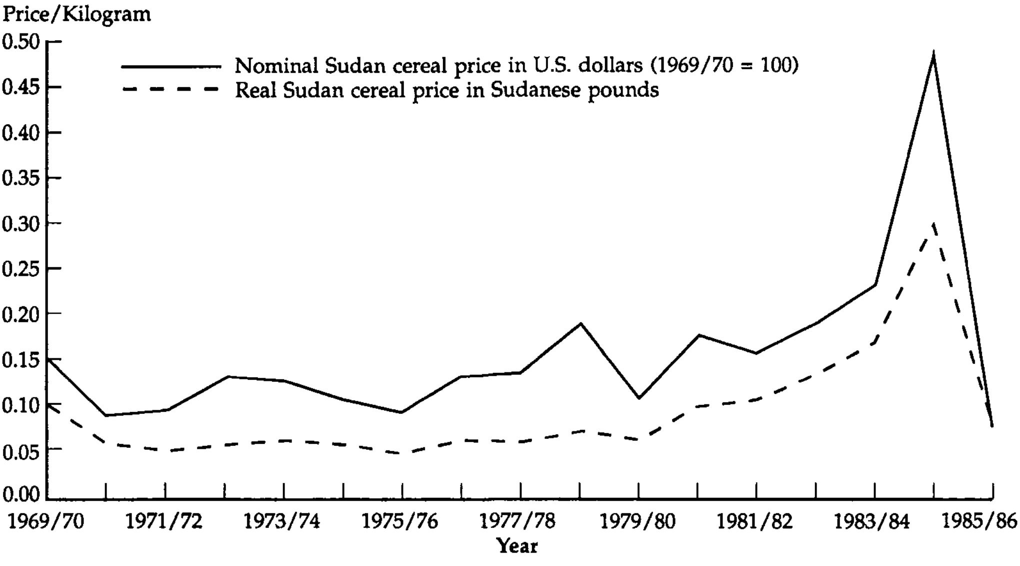
Notes: Gedaref is in the Eastern Region, El Obeid is in Kordofan Region, and Nyala is in Darfur Region; n.a. means not available.

[a]Weighted average of Gedaref sorghum and Nyala millet wholesale prices.

Cereal prices continued to increase and stayed at high levels until the harvest of 1985. By the end of the 1985 harvest, prices had dropped to as low as 30 percent of the 1984 average.

The strong association of production and price variability in cereals in the short run is also evident in the case of sesame. Its price increased in 1984, albeit modestly compared with cereal crops, and continued to rise during the 1985 season because of the poor harvest.

Figure 8—Cereal real price versus nominal price in Sudan, 1969/70–1985/86



Source: Computed from price series data compiled from various publications of the Ministry of Agriculture and Natural Resources, Department of Agricultural Economics.

Table 38—Average monthly wholesale prices for sorghum, millet, sesame, and cattle in selected markets, October 1983-January 1986

Period	Sorghum		Millet	Sesame	Cattle	
	Gedaref	El Obeid	El Obeid	El Obeid	Nyala	El Obeid
	(SD£/100 kilograms)				(SD£/head)	
October 1983	24.95	29.32	48.23	110.98	336	318
January 1984	26.94	32.24	51.22	94.50	287	296
April 1984	32.81	40.98	60.94	...	...	...
July 1984	37.85	56.97	n.a.	94.02	254	292
October 1984	102.08	136.68	n.a.	126.63	142	172
January 1985	107.21	122.70	146.35	197.86	241	121
July 1985	119.02	151.03	151.57	190.57	185	368
October 1985	63.91	103.22	n.a.	191.02	395	473
January 1986	36.17	40.55	72.93	196.00	787	672

Sources: Sudan, Ministry of Agriculture and Natural Resources, *Agricultural Prices in Sudan: A Historical Review and Analysis, 1970-1984* (Khartoum: MANR, *1985); MANR, Agricultural Situation and Outlook: 1986-1987* (Khartoum: MANR, *1987); and MANR, Current Agricultural Statistics: 1984/85 and 1985/86* (Khartoum: MANR, *1988).*

Note: Gedaref is in the Eastern Region, El Obeid is in Kordofan Region, and Nyala is in Darfur Region.

The picture is different in the case of livestock. Prices of livestock dropped significantly in 1984, particularly in the months that coincided with the peak rise in cereal prices. In Nyala market in the west, the price of cattle per head dropped from SD£254 in July 1984 to SD£142 in October 1984. The price reached SD£121 in El Obeid market in January 1985. In rural markets, the price drop was much greater. For example, in Bara market in Northern Kordofan, the price of cattle was down to SD£48 per head in April 1985. Prices recovered strongly, however, and continued to rise at a much faster rate after mid-1985. This dramatic price increase slowed recovery, particularly among those who used to own small herds.

The patterns of these price movements remains unchanged even when they are deflated to account for changes in the general price level. It is evident that 1984, which witnessed large increases in cereal prices, was also a year of large increases over the general price level of 1983. The increasing trends in the general price level suggest that real commodity prices were lower than nominal prices but followed a path similar to the movement of nominal prices.

Relative Price Movements

For farm households that grow cash crops or produce livestock, their purchasing power and ability to acquire staple foods is largely determined by the terms of trade between food and the households' farm produce for the market. Similarly, for rural wage earners, the ability to acquire food depends considerably on the level of food prices versus the (cash) wage rate. Data on rural wage rates are unfortunately not available. Therefore, the following assessment concentrates on the terms of trade between staple foods, on the one hand, and cash crops and livestock, on the other.

The relative price movements between sorghum and the two main cash crops—sesame and groundnuts—are shown in Table 39. The evolution of these relative prices reveals that the terms of trade deteriorated dramatically during the 1984-85 food shortage. For example, the terms of trade between sesame and sorghum in the Central and Eastern regions fell from 0.73 to 0.32 between 1974-78 and 1984. This suggests that the same amount of sesame could buy less than half (44 percent) as much sorghum in 1984-85 as in the 1974-78 period. Similarly in Kordofan, the terms of trade declined to 0.34 in 1984 from 0.56 in 1974-78. The deterioration was much greater in the case of groundnuts. The price of groundnuts in terms of sorghum dropped from 1.1 in 1974-78 to 0.54 in 1984 in Kordofan, that is, the same amount of groundnuts could buy only half as much sorghum in the drought year of 1984. While cash crops tended to provide a reasonably reliable income source for farmers in normal years, their contribution to real income in food-crisis years, such as 1984-85, rapidly deteriorated.

The evolution of the terms of trade between cattle and sorghum and between goats and sorghum is shown in Table 40. Goats are the most commonly owned animals and provide an important source of income, particularly among the low-income households. Cattle are the most preferred animals, particularly among pastoralists who are settled south of 13° north latitude.

The price of cattle in terms of sorghum continuously deteriorated over the years until 1985, when there was a turnaround. The terms of trade were dramatically low in 1984 compared with the previous years. Cattle producers could buy only about one-tenth of the sorghum that they could in 1979 per head of cattle. In other words, producers had to provide about 8 to 10 times more cattle to acquire the same amount of sorghum in return in 1984 as in 1979. This was more or less consistently the case in central Sudan as well as in Kordofan and Darfur regions. The deterioration in the terms of trade between cereals and small ruminants was comparatively smaller.

Table 39—Terms of trade between cash crops and staple foods, as ratio of price indices, 1974-85

	Central/Eastern Regions	Kordofan Region		Darfur Region
Period	Sesame Price Index/Sorghum Price Index	Groundnut Price Index/Sorghum Price Index	Sesame Price Index/Sorghum Price Index	Sesame Price Index/Millet Price Index
	(Index: 1979 = 1.00)			
1974-78	0.73	1.05	0.56	1.09
1980-81	0.75	1.14	0.43	0.49
1982-83	0.65	1.01	0.58	0.64
1984	0.32	0.54	0.34	0.45
1985	0.96	2.13	0.96	1.01

Sources: Sudan, Ministry of Agriculture and Natural Resources, *Agricultural Prices in Sudan: A Historical Review and Analysis, 1970-1984* (Khartoum: MANR, 1985); MANR, *Agricultural Situation and Outlook: 1986-1987* (Khartoum: MANR, 1987); and MANR, *Current Agricultural Statistics: 1984/85 and 1985/86* (Khartoum: MANR, 1988).

Table 40—Terms of trade between livestock and sorghum, as ratio of price indices, 1974-85

Period	Central/Eastern Regions: Cattle Price Index/ Sorghum Price Index	Central/Eastern Regions: Goat Price Index/ Sorghum Price Index	Kordofan Region: Cattle Price Index/ Sorghum Price Index	Kordofan Region: Goat Price Index/ Sorghum Price Index	Darfur Region: Cattle Price Index/ Sorghum Price Index	Darfur Region: Goat Price Index/ Sorghum Price Index
			(Index: 1979 = 1.00)			
1974-78	0.63	0.96	0.47	0.61	0.85	0.93
1980-81	0.60	0.63	0.46	0.55	0.51	0.60
1982-83	0.32	...	0.31	0.47	0.37	0.47
1984	0.12	0.14	0.09	0.17	0.11	...
1985	0.68	0.67	1.06	1.02	1.39	...

Sources: Sudan, Ministry of Agriculture and Natural Resources, *Agricultural Prices in Sudan: A Historical Review and Analysis, 1970-1984* (Khartoum: MANR, 1985); MANR, *Agricultural Situation and Outlook: 1986-1987* (Khartoum: MANR, 1987); and MANR, *Current Agricultural Statistics: 1984/85 and 1985/86* (Khartoum: MANR, 1988).

Seasonality of Prices

Regular intrayear variations in cereal prices follow a unimodal distribution in conformity with the annual production cycle. In the case of sorghum, prices start from seasonal lows in December as the new harvest comes into the markets. Prices show modest rises in the consecutive months between January and May, then faster growth in the wet-season months from July to October. The months between July and October represent high points, with the peak in October (Table 41). The seasonal price spread averages a monthly growth rate of 2 percent.

Table 41—Seasonal price indices for sorghum, millet, and cattle in selected markets, 1980-82

Commodity/ Market	January	April	July	October	Highest Month	Lowest Month	Seasonal Increment
		(percent)					(percent)
Sorghum							
Gedaref	94.5	99.2	102.6	111.4	October	December	18.7
El Obeid	93.1	99.2	101.3	109.4	October	January	16.3
Millet							
El Obeid	97.3	98.0	97.7	106.6	November	n.a.	16.3
Cattle							
Nyala	102.4	104.2	99.8	92.3	March	October	16.5

Source: Sudan, Ministry of Agriculture and Natural Resources, *Seasonal Movements in Sudan's Agricultural Commodity Prices* (Khartoum: MANR, 1988).

Notes: The indices were derived using 12-month centered moving average techniques applied to a multiplicative model. n.a. means not available.

The months between December 1984 and October 1985 exhibited a marked departure from regular seasonal behavior. The price of sorghum rose rapidly in the postharvest months, shifting the seasonal high points to the months between February and June. In fact, record high prices were experienced during these months. The price then dropped unseasonably low between August and October 1985. The unseasonable price decline suggests revised expectations on the part of traders in anticipation of a good harvest in 1985 or the injection of new supply into the markets or both. In addition to shifts in the high and low months, the period witnessed an average monthly growth of 10 percent in price. The seasonal amplitude was dramatic compared with the regular seasonal increment of 2 percent a month.

Intrayear variability in cattle prices is influenced by the north-south movements of cattle-herding nomads. Sales of cattle begin to rise in July as these nomads move into the vicinity of markets. Trading activity peaks in the months between August and October, and these three months account for nearly 40 percent of annual sales. Sales begin to fall off after October as the nomads return southward. Trading in the months between November and January accounts for 25 percent of annual sales. The period of lowest trading activity starts in February and continues until June.

Monthly prices of cattle tend to follow the seasonal pattern of availability. The price in the Nyala market begins to drop in July and stays at seasonal lows between August and November. The price starts to rise in December and continues at a high level until July (Table 41). On average, the price increases 16 percent from the seasonal low in October.

The 1984/85 cattle prices in Nyala showed two periods of seasonal lows; the first covered September through November and the second was from March through June (Table 42). The second period coincided with the period of the failed

Table 42—Average monthly prices for cattle at Nyala and Bara markets, 1984/85

Year/Month	Nyala	Bara
	(SD£/head)	
1984		
July	254	203
August	336	188
September	145	189
October	142	143
November	125	116
December	182	89
1985		
January	241	95
February	258	83
March	151	58
April	155	48
May	129	62
June	128	73

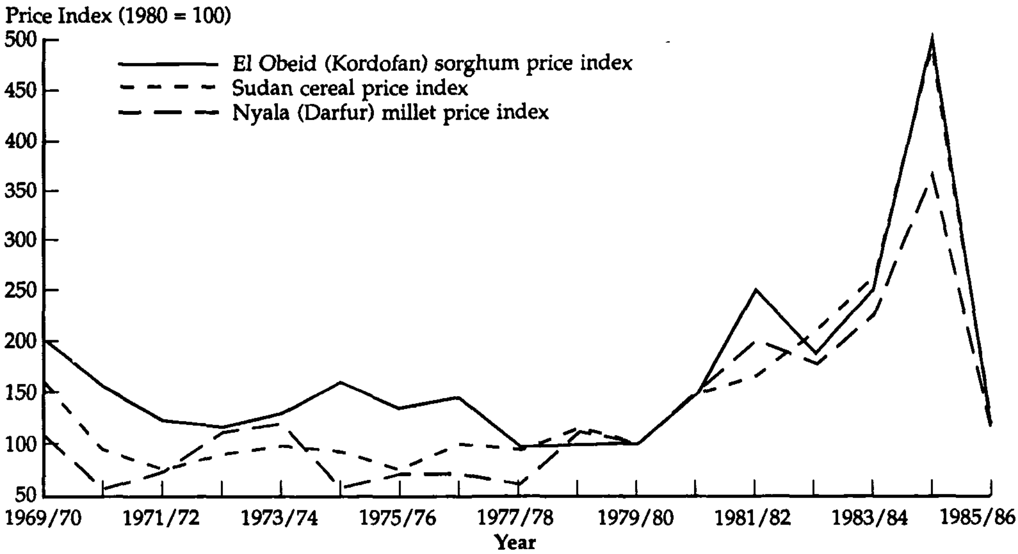
Source: Based on data files of the Relief and Rehabilitation Commission, Khartoum.
Note: Nyala is in Southern Darfur Province; Bara is in Northern Kordofan Province.

1984 harvest and is indicative of the presence of nomads and a large entry of livestock into the market. A more dramatic pattern was, in fact, evidenced in a town market in Bara district in Northern Kordofan, where the price decreased continuously from October 1984 to April 1985. This district typifies areas hard hit by the drought and poorly connected to regional markets.

Regional Market Disconnection

The price index for cereals for the whole country (computed as a weighted average using production shares by region as weights for the prices prevailing in the regions) is contrasted with the local price development in Kordofan and Darfur regions in Figure 9. It reveals that, while many wide differences prevailed between the regions when prices were not excessively high in the 1970s, the general price movement during the food crisis in 1984-85 was apparently spread all over the country. However, similar relative movements mean quite different absolute movements in price levels across regions. This is highlighted by the evolution of the interregional price differences of foodgrains in the case of sorghum. In the 1980s, sorghum prices in Kordofan tended to be 20-25 percent higher than in the eastern sorghum-producing area (Gedaref), and prices in Darfur tended to be more than two times those in Gedaref, while they exceeded Kordofan prices by about 80

Figure 9—Price indices for Kordofan sorghum, Darfur millet, and Sudan cereals, 1969/70–1985/86



Sources: Computed from price series data in Sudan, Ministry of Agriculture and Natural Resources, Department of Agricultural Economics, *Agricultural Prices in Sudan: A Historical Review and Analysis, 1970–1984* (Khartoum: MANR, 1985); *Agricultural Commodity Prices, 1985 Summary* (Khartoum: MANR, 1986); and *Agricultural` Commodity Prices, 1986 Summary* (Khartoum: MANR, 1987).

percent (see price ratios after 1982/83 in Table 43). Nevertheless, price wedges between regions appear lower in the 1980s than in the 1970s. Thus, overall market integration may have improved.

A statistical model based on the work of Ravallion (1986) and Timmer (1974) is applied to examine some elements of market integration in grain and livestock markets. The model postulates that changes in local market prices are caused by a change in the spatial margin between local and reference markets, a change in the temporal margin in the reference market, the level of price in the reference market, and local specific factors. The specific equation chosen for estimation is

$$P_{it} = \alpha_i P_{it-1} + \beta_i (R_t - R_{t-1}) + \theta_i R_{t-1} + \Phi_i D85 + \underset{\sim}{\Gamma} \underset{\sim}{X} + U_{it}, \quad (5)$$

where

P_{it} = monthly wholesale price in market i in period t,
R_t = reference market monthly wholesale price in period t,
D85 = dummy variable (1 for month in 1984-85; 0 otherwise),
$\underset{\sim}{X}$ = vector of local specific market-conditioning factor, and
U_{it} = random error term in market i in period t.

Table 43—Interregional wholesale price differences for sorghum, 1969/70-1985/86

Season	Sorghum		
	Kordofan/Central Ratio	Darfur/Central Ratio	Darfur/Kordofan Ratio
	(ratio of deflated prices per kilogram)		
1969/70	1.72	1.55	0.90
1970/71	2.08	1.24	0.60
1971/72	2.84	2.48	0.87
1972/73	2.66	2.17	0.81
1973/74	2.11	3.74	1.77
1974/75	2.07	1.35	0.65
1975/76	2.59	4.12	1.59
1976/77	1.90	4.37	2.30
1977/78	1.27	2.73	2.15
1978/79	1.40	2.47	1.77
1979/80	1.56	4.01	2.57
1980/81	1.56	2.95	1.88
1981/82	2.45	3.75	1.53
1982/83	1.20	2.13	1.78
1983/84	1.27	2.26	1.78
1984/85	1.31	...	...
1985/86	1.35	...	...

Sources: Sudan, Ministry of Agriculture and Natural Resources, *Agricultural Prices in Sudan: A Historical Review and Analysis, 1970-1984* (Khartoum: MANR, 1985); MANR, *Agricultural Situation and Outlook: 1986-1987* (Khartoum: MANR, 1987); and MANR, *Current Agricultural Statistics: 1984/85 and 1985/86* (Khartoum: MANR, 1988).

The parameter β_i measures the proportional change in the local price caused by a change in the temporal margin in the reference market. A sizable positive value indicates that local prices track with movements in reference market prices, that is, traders monitor changes in reference market prices and adjust local prices accordingly. θ_i measures the influence of the reference market price level (R) on local prices. An increase in the price level may induce local traders to adjust accordingly, particularly in an environment experiencing rapidly increasing prices. Φ_i captures the effects of unseasonal price movements in the 1984-85 period. The vector Γ captures the proportional contribution of factors specific to local price changes.

It is plausible to assume that in the Sudan case the principal regional markets exhibit marked long-term price relationships. A study in Darfur, for example, concludes that the informal market information network among traders is very strong (Darfur Regional Government 1988). The existence of such communication flows suggests that the β_i coefficient may be close to 1, that is, there is a neutral proportional change. But a high β_i may simply reflect the effect of general economic and market forces that show up in apparent market integration (similar to the argument applicable to the coefficient of correlation measure). It may be possible, however, that traders may fail to connect markets through commodity flows in the short run. Therefore, Timmer's indirect but more general measure of market integration is invoked here. It is defined as the ratio of the local market coefficient (α_i) to the reference market coefficient (θ_i), that is,

$$\text{Index of Market Connection (IMC)} = \alpha_i/\theta_i. \qquad (6)$$

An IMC greater than 1 indicates poor connection across markets. The relative contributions of local price history are the primary factors in the current level of local prices. An extreme case where the IMC is ∞ implies that markets are segmented ($\theta = 0$). An IMC of less than 1 implies a high degree of market connection. The IMC indicates greater connection as it approaches zero, and when IMC = 0, it suggests that changes in reference market prices are fully reflected in local prices in the short run ($\theta = 1$ and $\alpha_i = 0$).

In order to test the extent of market integration in sorghum and cattle markets, four principal regional markets were selected—Nyala in Darfur Region, El Obeid in Kordofan Region, Omdurman in Central Region, and Gedaref in Eastern Region. Omdurman is the main terminal market for cattle. Large supplies of cattle come from the western regions through the Nyala and El Obeid markets. Gedaref is both the main producer and the main market for sorghum. Even though El Obeid market is largely supplied from the surrounding areas, particularly Southern Kordofan Province, there is sizable competition for trading between the regions.

Changes from month to month in the price of cattle in Nyala and El Obeid were related to Omdurman monthly prices for the period 1981-86. El Obeid market was also used as the reference for the Nyala market. El Obeid sorghum wholesale prices were also related to Gedaref prices for the 1982-86 period. A choice of one month as a time interval is considered a reasonable span for the flow of information and commodities in Sudan's context. This assumption may need to be relaxed for cattle. All the variables are in logarithms, following the tradition of previous work. The parameter estimates of equation (5) are given in Table 44. A summary of measures of integration is in Table 45.

Table 44—Regression coefficients for tests of regional market integration

Commodity	Regional Market	Reference Market	Independent Variables[a] P_{it-1}	$R_t - R_{t-1}$	R_{t-1}	D85	Constant	LLF	DW	DF
Sorghum (*feterita*)	El Obeid	Gedaref	0.55 (4.97)	1.08 (18.45)	0.45 (3.64)	0.04 (0.72)	0.06 (0.47)	44.26	1.93	55
Cattle	El Obeid	Omdurman	0.72 (8.22)	0.78 (12.08)	0.24 (2.31)	. . .	0.15 (0.48)	-403.82	2.07	68
	Nyala	Omdurman	0.75 (8.62)	0.73 (8.05)	0.20 (1.67)	. . .	0.21 (0.49)	-424.81	2.22	68
	Nyala	El Obeid	0.43 (3.82)	0.95 (12.78)	0.60 (4.54)	. . .	-0.17 (-0.07)	-410.70	2.17	68

Source: Based on data files of the Ministry of Agriculture and Natural Resources, Department of Agricultural Economics, Marketing Section, Khartoum.
Note: Figures in parentheses are t-values.
[a] P_{it} = monthly wholesale price in market i in period t, and
R_t = reference market monthly wholesale price in period t.

Table 45—Index of market integration for sorghum and cattle regional markets, 1982-86

Commodity	Regional Market	Reference Market	$\hat{\beta}_i$	IMC
Sorghum	El Obeid	Gedaref	1.08	1.22
Cattle	El Obeid	Omdurman	0.78	2.98
	Nyala	Omdurman	0.73	3.68
	Nyala	El Obeid	0.95	0.71

Source: Computed from regression coefficients in Table 44.
Note: $\hat{\beta}_i$ represents a measure of the proportional change in the local price caused by a change in the temporal margin in the reference market. IMC (index of market connection) represents the ratio of the local market coefficient (α_i) to the reference market coefficient (θ_i).

The statistical significance of the β_i and θ_i coefficients suggests that commodity markets are not segmented. In fact, the high β_i coefficients for sorghum and cattle show that the regional markets in the west have a strong long-term integration with the principal markets in the Central and Eastern regions. Inclusion of dummy variables for the 1984-85 months had little impact on the stability of the coefficient estimates. The price effect of 1984 was nonlocalized and did not have an impact on overall market integration.

Traders have a well-functioning information network for following price developments in distant regional markets. Such an information flow is not, however, complemented by strong connections in the short term. The IMC ratios are greater than 1 for all markets, except those between Nyala and El Obeid. The connections are particularly poor for cattle markets and are worst for Nyala, the most distant market. It is estimated that about 95 percent of the animals traded between western Sudan and other regions are trekked. The route from Nyala to Omdurman is about 1,400 kilometers, and the journey takes about 60 days during the rainy season (Babiker 1986), which partly explains the poor connection.

Markets appear to operate and to transmit price signals across regions. Even though such long-term regional price relationships exist and remain unaffected in periods of acute production shortfalls, poor market connections preclude markets from clearing at low levels because of high market-transaction costs. Transportation alone accounts for, on average, 10-15 percent of consumer price. A sample of market areas shows that the share of transportation ranges between one-fifth and nearly one-half of total marketing costs (Table 46). Ahmed and Rustagi (1987) also conclude, on the basis of their survey of African countries, that the share of transport varies from 35 to 50 percent of the total marketing cost. Moreover, they point out that the absolute transport cost in marketing is about twice as high in Africa as in Asia. This cost is largely associated with the poor road network, which is also evident from the comparison of transport shares in the sample of eastern and western market areas in the present study. The transport cost share is higher in western market areas, where the rural road network is less developed (Figure 10).

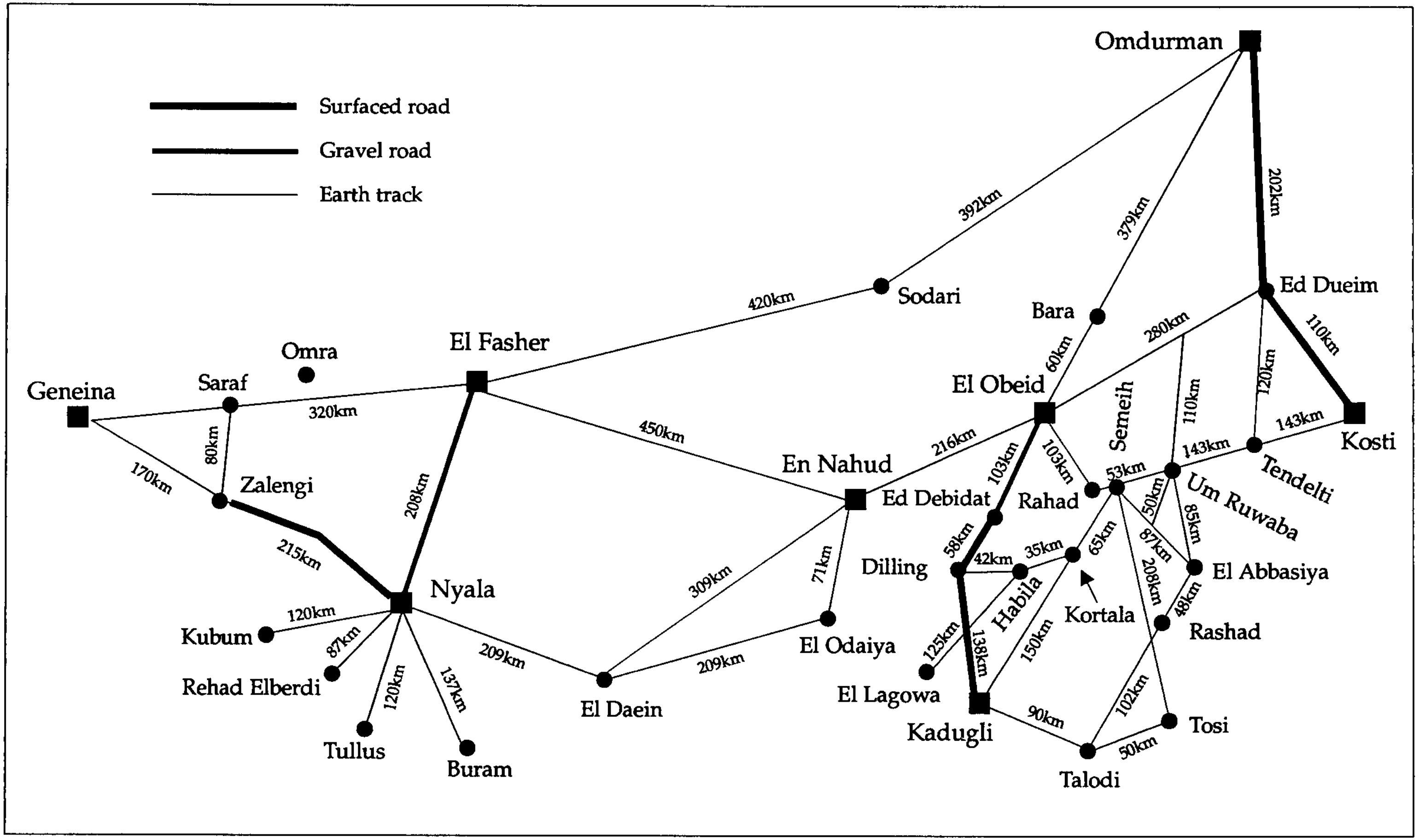
Other principal marketing cost components are storage and cost premiums associated with weight loss (Table 46). The two account for 20-40 percent of total

Table 46—Shares of marketing cost components for sorghum and millet, 1985-87

Commodity	Production Area	Consumption Area	Region	Year	Component Share				
					Transport	Handling	Taxes	Storage[a]	Weight Loss
							(percent)		
Sorghum (*feterita*)	El Doka/Gedaref	Gedaref	Eastern	1985/86	20.5	13.9	26.8	15.8	12.8
				1986/87	36.0	5.8	30.0	5.3	10.9
	Habila/Southern Kordofan	El Obeid	Kordofan	1985/86	39.0	10.1	6.8	21.7	18.7
				1986/87	44.5	6.5	8.4	23.4	11.9
	Nyala	Nyala	Darfur	1986/87	47.4	12.3	7.0	12.2	15.6
Millet	El Obeid	El Obeid	Kordofan	1985/86	38.8	8.8	7.9	12.1	29.2
	Nyala	Nyala	Darfur	1985/86	45.5	11.0	. . .	13.4	22.8

Source: Based on data files of the Ministry of Agriculture and Natural Resources, Marketing Section, Khartoum, 1988.
[a]Storage includes the interest charge on working capital.

Figure 10—Road transportation network in western Sudan



Source: Based on Sudan, Ministry of Finance and Economic Planning, *Western Sudan Transport Study*, Main Report, vol. 1 (Khartoum: 1984).

marketing costs. The weight loss component of the marketing cost is greater for millet than for sorghum. Poor storage practices for millet contribute, for example, to a low price in the wet season, when other crops are at their height. In general, significant seasonal price variation due to the high cost of transfer across time characterizes cereal prices in Sudan.

Although information on the actual marketing costs during the food crisis is not available, it is clear that marketing costs were prohibitive in many instances where people were prepared to move to the food rather than expecting that the food would move to the people who still had the required purchasing power. A large share of the interregional migration is due to drought and food shortage, especially in western Sudan, where there is the combined effect of lack of food and lack of employment locally.

Short-Term Price Flexibility in Cereal-Livestock Terms of Trade

When drought hits an industrialized country with well-developed infrastructure, farm price increases of 10-20 percent, such as occurred in the 1988 drought in the United States, are considered large. Adjustments in stockholdings and trade permit a considerable degree of price stabilization under such conditions. Doubling or trebling of prices, as happened during the 1984 drought in Sudan, appears to be largely production-driven.

The key points quantitatively tested in the study are the degree to which production fluctuations—which were determined to be much influenced by the drought events above—result in price fluctuations, and the extent to which trade (including food aid) and stockholding are able to mitigate the fluctuations. The price-formation process is certainly complex and, in principle, requires a simultaneous look at the supply and demand sides and all the factors that determine each of these as well as due consideration of the expectations of agents on the supply and demand side of the market equations. With given data limitations, rather simple approaches are chosen here to explain price flexibility. The focus is on annual price fluctuations, and the demand side is not explicitly modeled. To the extent that short-term purchasing power is affected by production volume and price-level changes as well as price-ratio change (that is, cereal-livestock terms of trade), these are implicitly taken into account in the reduced-form model estimates chosen. First, an attempt is made to explain current-year cereal prices (in real terms) by total domestic supply and the previous year's ending stock levels:

$$PICER = f(CERS_t, STOCK_{t-1}), \tag{7}$$

where

$CERS_t$ = $CERP_t + IMP_t + FAID_t - EXP_t$,

$PICER_t$ = index of the Sudan cereal price (deflated production-weighted mean of regional prices) in year t,

$STOCK_{t-1}$ = level of cereal stocks per capita at end of year t−1 (or beginning-year stocks), in kilograms,

$CERP_t$	= cereal production per capita in year t, in kilograms,
IMP_t	= imports per capita in year t,
$FAID_t$	= food aid per capita in year t,
EXP_t	= net of exports per capita in year t, and
$CERS_t$	= total supply of cereals per capita from production ($CERP_t$), imports (IMP_t), net of exports (EXP_t), and food aid ($FAID_t$).

Second, the extent to which domestic production alone drives the price fluctuations is tested by excluding the trade and aid component from equation (7), that is, setting the index of cereal price as a function of current production per capita and previous-year cereal stocks per capita:

$$PICER = f(CERP_t, STOCK_{t-1}). \tag{8}$$

The same model estimation exercise is then repeated for the cereal-livestock terms of trade as

$$CLTOT_t = f(CERS_t, STOCK_{t-1}), \text{ and} \tag{9}$$

$$CLTOT_t = f(CERP_t, STOCK_{t-1}). \tag{10}$$

The models hypothesize that the real price index of cereals increases with a drop in domestic cereal production in the same year, but decreases when the last year's ending stocks or current year's opening stocks, respectively, are increased. Similarly, it is hypothesized that the terms of trade between cereals and livestock commodities are largely driven by the same set of hypotheses. The determinants of the cereal-livestock terms of trade may in fact be even more complex than the determinants of cereals' real price development because of the complex interactions between cereal markets and livestock markets, the differential effects of drought on cereal and livestock supply (distress sales of livestock drive prices down), and the adverse effects of increased cereal prices on the demand for livestock commodities by households. Again, a rather simple approach is taken here due to data limitations. The parameter estimates and estimation results are presented in Table 47.

With the help of the estimated parameters, the effects of a change in production of –10 percent and –30 percent, as well as a similar change in stocks, were derived for the cereal price and for the terms of trade. The results suggest that a drop of 30 percent in cereal production per capita raises cereal prices by 78 percent (equation [8] in Table 48). The order of magnitude is similar, resulting from a drop of 30 percent in production, for the cereal-livestock terms of trade: the terms of trade will increase by 57 percent (equation [10]). Holding other things constant, a decrease of 30 percent in cereal stocks would raise prices by 24 percent and the terms of trade by 18 percent. Similar models were run separately for Kordofan and Darfur, and these showed, relatively speaking, somewhat lower effects of local production fluctuations for local prices and local terms of trade, respectively. Given some domestic interregional trading, this outcome should be expected (Table 48).

Table 47—Regression equations for explanation of price flexibility and domestic terms-of-trade flexibility

Equation/ Dependent Variable	Explanatory Variables[a]			Constant	$\bar{R}^2$	F
	$CERP_t$	$CERS_t$	$STOCK_{t-1}$			
(7) PICER	...	-2.949 (-3.02)	-5.588 (-2.71)	725.29	0.436	5.0
(8) PICER	-2.775 (-5.31)	...	-4.355 (-3.46)	639.20	0.700	15.0
(9) CLTOT	...	-0.0251 (-5.68)	(-0.0456 (-4.90)	6.332	0.685	17.3
(10) CLTOT	-0.02037 (-9.81)	...	-0.03179 (-6.36)	5.069	0.887	50.9

[a] Parameters; t-values are in parentheses.

Definitions of variables:

$CERP_t$ = cereal production per capita, in kilograms;
$CERS_t$ = total supply of cereals per capita from production, imports, net of exports, and food aid;
$STOCK_{t-1}$ = level of cereal stocks per capita at end of year t-1, or beginning year stocks, in kilograms;
PICER = index of the Sudan cereal price (deflated production-weighted mean of regional prices); and
CLTOT = cereal-livestock terms of trade.

The main conclusion from this analysis is that, as a 1 percent drop in production at the national level tends to lead to about a 2.0-2.5 percent increase in prices in the short term, policies for production stabilization, stockholding, and facilitation of interregional trade are of critical importance. It may be most difficult to increase the short- and medium-run stability in cereal production given the dominance of the rainfed sector in this production. A fresh look at optimum storage levels, at

Table 48—Effects of production and stock changes for cereal prices and cereal-livestock terms of trade

Dependent Variable	Production Change		Stock Change	
	-10 Percent, Equations (8) and (10)	-30 Percent, Equations (8) and (10)	-10 Percent, Equations (8) and (10)	-30 Percent, Equations (8) and (10)
	(percent)			
Sudan cereal price	26.0	77.9	8.0	24.1
Sudan cereal-livestock terms of trade	19.1	57.3	5.9	17.6
Kordofan sorghum price	12.0	36.0	4.2	12.5
Kordofan sorghum-livestock terms of trade	12.6	37.7	3.6	10.7
Darfur millet price	14.7	44.2	2.8	8.5

Source: Computed from mean values of variables and parameters in Table 47.

investment in rural infrastructure for interregional trade, and at the option of stabilization through international trade in cereals requires consideration (see Pinckney 1989 on this issue). Research into the trade-offs between these options, which are not further explored here, could have a high payoff.

Price fluctuations are found to be driven predominantly by production fluctuations. The respective parameters estimated for CERS (total supply, including trade) change very little if production only is substituted (compare CERP and CERS parameters in Table 47). In fact, the explanatory power of the model decreases when total supply, rather than production only, is considered in the specification. Such a decrease may be explained by the timing of trade (aid) arrivals within the year, but this is only speculation.

6

IMPLICATIONS OF DROUGHT AND FAMINE FOR CONSUMPTION AND NUTRITION

Available evidence on Sudan suggests that households respond in varying degrees to income and price changes. The poor spend more than richer households on staple crops and are much more responsive to price and income changes. Hence, adjusting to drought-induced price and income changes is harder for the poorer households. An attempt is made here to pool available information on food and nutrient consumption in order to review and assess the impact of the 1984 drought, especially the aggregate and distributional effects of the drought on food and calorie demand and on nutritional-status indicators.

Food and Nutrient Consumption Practices

The studies reviewed here are based on a 1978-80 household consumption and expenditure survey (Sudan, Ministry of Finance and Economic Planning 1982). This chapter benefited from the work of Yisehac Yohannes (1989). The raw data from Darfur and Kordofan in the 1978-80 survey are utilized here for the first time to derive income and price response parameters. The information from these studies establishes the "normal" consumption situation preceding the 1984-85 famine.

The Sudanese spent about two-thirds of their average income on food during the 1978-80 period (Tables 49 and 50). There are, however, notable variations in

Table 49—Per capita expenditure and food share, by province and location, 1978-80

Province	Per Capita Expenditure	Food Share
	(SD£/month)	(percent)
Khartoum, urban	20.8	62.7
Khartoum, rural	12.5	73.7
Gezira	13.9	67.6
White Nile	9.3	68.0
Blue Nile	8.9	74.3
Nile	11.9	73.3

Sources: Based on Angus Deaton and Anne Case, *Income Distribution, Poverty, Expenditure Patterns and Price Elasticities in the Sudan*, Report to the USAID mission to Sudan, 1985; and data files from the Ministry of Finance and Economic Planning, Khartoum.

Table 50—Per capita expenditure and income, family size, food share, and calorie consumption, by province and income quartile, 1978-80

Province/ Income Quartile	Per Capita Expenditure	Per Capita Income	Family Size	Food Share	Calorie Consumption
	(SD£/year)			(percent)	(kilocalories/ person/day)
Northern Kordofan	103.5	124.3	6.7	61.5	2,566
Northern Darfur	128.9	140.9	5.5	52.8	2,427
Northern Kordofan					
Quartile 1	53.27	67.88	8.5	68.2	1,667
Quartile 2	83.74	98.25	6.1	60.7	2,236
Quartile 3	107.62	132.62	6.4	62.8	2,869
Quartile 4	169.41	198.27	5.7	54.5	3,482
Northern Darfur					
Quartile 1	51.37	84.34	6.2	59.5	1,724
Quartile 2	89.25	64.96	5.8	59.2	2,297
Quartile 3	135.74	104.37	5.4	47.5	2,417
Quartile 4	237.92	309.15	5.4	45.0	3,247

Source: Based on data tape from the Ministry of Finance and Economic Planning, Department of Statistics, Khartoum.

the size of these shares among regions. A comparison of urban and rural Khartoum shows that the rural population allocated more of its income to food. The shares across provinces appear to follow the expected inverse relation between income level and food share, except for the western provinces of Northern Kordofan and Northern Darfur, and White Nile Province in Central Region. Shares were greater in Blue Nile and Nile provinces relative to Gezira and urban Khartoum, reflecting partly the low income level in the Nile provinces.

The expected inverse relationships are more regular among income groups within the same regions. In Northern Kordofan, for example, the poorest households (those in the bottom 25 percent of income distribution) allocated, on average, 14 percent more of their income to food than did the upper 25 percent (Table 50). The same pattern of behavior in the food share is observed in the Northern Darfur sample. In fact, share elasticity estimates for these provinces range between −0.44 (Northern Kordofan) and −0.45 (Northern Darfur); that is, food share drops by 0.5 percent for a 1.0 percent increase in per capita expenditure. Income allocated to food decreases at the margin with an increase in income level.

The average person in the west, particularly in Northern Kordofan and Northern Darfur, spent no less than 30 percent of the food budget on cereals (Table 51). Millet was the most prominent item in the food budget. Sorghum, the dominant staple in central and eastern Sudan, was a distant second, averaging about 10 percent in the west. Other important food groups were sugar, vegetables, and meats. A relatively high share of sugar in the food budget is characteristic of a Sudanese diet.

The allocation of food budgets across these food components appears to vary with income level. The case of Northern Darfur in 1978-80 is presented in Table 52. The food shares for cereals decline with income—from 45 percent in the lowest

Table 51—Share of food components in total food budget, by province, 1978-80

Food	Northern Kordofan	Northern Darfur	Southern Darfur
		(percent)	
Cereals[a]	35.23	32.60	30.17
Sorghum	12.42	5.50	5.57
Millet	21.83	26.08	23.47
Cereal products[b]	0.58	0.68	1.41
Vegetables	7.74	7.61	8.21
Milk	2.81	2.80	3.73
Meat	9.22	15.32	14.25
Sugar	16.84	14.40	17.57
Beverages[c]	10.74	3.63	5.07
Oils and fats	9.62	7.46	8.70
Condiments	3.70	3.63	3.27
Other	3.52	11.87	7.62

Source: Based on Yisehac Yohannes, "Food Consumption Patterns in Western Sudan, 1978-80," Famine and Food Policy Discussion Paper 1 (International Food Policy Research Institute, Washington, D.C., 1990, mimeographed).
[a]Cereals are sorghum, millet, maize, wheat, barley, rice, and others.
[b]Cereal products are wheat flour, *kisra*, and bread.
[c]Beverages are nonalcoholic drinks, tea, and coffee.

Table 52—Variation in food budget shares in Northern Darfur, by expenditure group, 1978-80

Food	Expenditure Group[a] Low	Medium	High
		(percent)	
Cereals	45.50	30.75	23.42
Sorghum	16.75	2.44	0.63
Millet	28.52	27.52	20.63
Vegetables	6.33	7.91	8.26
Milk	2.28	2.81	3.31
Meat	13.35	16.13	15.61
Sugar	9.03	15.41	17.65
Beverages	2.31	3.58	5.03
Oils and fats	5.39	8.24	7.90
Condiments	3.92	4.48	5.49
Other	11.89	10.69	13.33

Source: Based on data tape from the Ministry of Finance and Economic Planning, Department of Statistics, Khartoum.
[a]Low refers to the bottom 25 percent of expenditure distribution, medium to the 50th to 75th percentile, and high to the top 25 percent. The remaining 25 percent were not reported.

income bracket to 23 percent in the highest. The poor in this region thus tend to concentrate on cereals. The shares of other food groups, notably vegetables, meats, and sugar, appear to increase with income.

The behavior of these shares across income levels also establishes that these food groups are income-sensitive. Measuring such responses and drawing inferences are, however, tenuous exercises given the weak data base. Notwithstanding such qualifications, this study pooled selected demand elasticity estimates from other studies based on the same 1978-80 survey data in other provinces of Sudan (Table 53). The studies are not quite comparable in commodity coverage, location, and demand forms; however, they provide some noticeable patterns. First, the food groups are responsive to changes in relative prices and income level. Second, price and expenditure elasticities decline as average income level rises and the discretionary component of household budgets increases with income. The large drop of the expenditure elasticity in urban Khartoum may reflect the increasing diversity of foods and declining share of cereals in the food budget. The elasticities in urban Khartoum present lower bounds for the country. Cereals, for example, have an attribute of a normal good (that is, positive income elasticity), and higher coefficients are expected in other regions. Third, cereal products, sugar, and tea are more income-responsive than cereals. This is consistent with observed food share and income relation in Northern Darfur.

The nutritional dimension of these food groups contributes information essential for understanding variation in nutritional status among the population. The last

Table 53—Selected own-price and expenditure elasticities, 1978-80

Study	Demand Functional Form	Area	Commodity	Expenditure Group[a]	Elasticity: Own Price	Elasticity: Income/ Expenditure[b]
Pinstrup-Andersen et al., 1983	Linear expenditure system	Urban Khartoum	Cereals	Strata 1-2	−0.39	0.38
				Strata 3-4	−0.37	0.38
				Stratum 5	−0.29	0.18
			Bread	Strata 1-2	−0.81	0.79
				Strata 3-4	−0.68	0.71
				Stratum 5	−0.22	0.14
			Sugar	Strata 1-2	−1.00	0.99
				Strata 3-4	−0.92	0.97
				Stratum 5	−0.34	0.02
Deaton and Case, 1985	Log linear	Sudan[c]	Sorghum	All	−0.69	0.13
			Sugar	All	−0.64	0.57
			Tea	All	−0.50	0.50

Sources: Based on Pinstrup-Andersen et al., "Impact of Changes in Income and Food Prices on Food Consumption by Low-Income Households in Urban Khartoum with Emphasis on the Effect of Changes in Wheat-Bread Points" (International Food Policy Research Institute, Washington, D.C., 1983, mimeographed); and Angus Deaton and Anne Case, *Income Distribution, Poverty, Expenditure Patterns and Price Elasticities in the Sudan*, Report to the USAID mission to Sudan, 1985.

[a]Stratum 1 is 12.5 percent of the survey households with the lowest total expenditure per capita; strata 2, 3, and 4 are each the next highest 12.5 percent; and stratum 5 is the highest 50 percent.

[b]Pinstrup-Andersen et al. reported income elasticities, while Deaton and Case estimated expenditure elasticities.

[c]Excluding the western regions of Darfur and Kordofan.

column in Table 50 shows that the average daily energy consumption exceeds 2,400 calories in Northern Kordofan and Northern Darfur. If one assumes a threshold of 2,100 calories, availability of calories was adequate on average in these provinces in the 1978-80 period.

The cereal crops as a group contributed over 65 percent of the calorie level (Table 54). Millet, the predominant staple in the west, was the main source, contributing about half.

Despite average adequacy, however, calorie consumption was uneven across expenditure groups (see Table 50 for the west and Table 55 for urban Khartoum). Households in the lowest expenditure distribution were prone to calorie deficiency. Large variations, however, were not found only in households with low income. A previous study on urban Khartoum (Pinstrup-Andersen et al. 1983) identified the key attributes of calorie-deficient households as related to large family size, low allocation of income to food, and choice of diet (Table 55). Their findings show that the poor had large families and (unlike the calorie-deficient) spent more on food and placed a high priority on cheap calories. Calorie deficiency is, therefore, not strictly income-determined. If, however, one speculates that it is the poor who are likely to face low degrees of freedom in their income uses or pay high search costs to identify low-cost diets, or both, the calorie-deficient may then be found to be concentrated among the poor. Further inquiry is made into this with a directly specified calorie-consumption function of the form

$$\text{lnPCDCL} = \beta_0 + \beta_1 \text{ lnPCEXP} + \beta_2 \text{ lnPCEXP}^2 + \beta_3 \text{ HHSZ} + \beta_4 \text{ PRCE}, \qquad (11)$$

where

lnPCDCL = natural log of per capita daily calories,

lnPCEXP = natural log of annual per capita expenditure,

lnPCEXP^2 = square term of lnPCEXP,

HHSZ = household size,

Table 54—Share of food components in total calories, by province, 1978-80

Food	Northern Kordofan	Northern Darfur	Southern Darfur
Cereals	66.20	71.56	58.23
Sorghum	27.63	11.64	12.90
Millet	37.62	59.22	44.40
Cereal products	0.34	0.18	0.32
Vegetables	3.47	3.54	3.02
Milk	2.01	1.71	4.10
Meat	2.11	3.48	4.65
Sugar	7.42	4.41	8.36
Oils and fats	16.40	12.57	19.22
Other	2.05	2.55	2.10

Source: Based on data tape from the Ministry of Finance and Economic Planning, Department of Statistics, Khartoum.

Table 55—Variation in income, expenditure, calorie consumption, family size, food share, and calorie price, urban Khartoum, 1978-80

Strata	Population Share	Total Income Share	Calorie Sufficiency	Family Size	Per Capita Income	Per Capita Expenditure	Food Share	Calorie Price
	(percent)		(calories)	(persons)	(SD£/month)		(percent)	(SD£)
Calorie[a]								
Stratum 1	19.81	12.83	−960.84	9.3	15.11	12.06	41.02	0.114
Stratum 2	18.75	14.75	−240.05	8.7	18.17	16.62	41.62	0.106
Stratum 3	17.84	16.69	+233.24	7.8	21.82	17.49	47.85	0.107
Stratum 4	44.20	56.33	+1,698.03	5.4	29.72	37.10	49.42	0.110
All	100.00	100.00	+566.77	6.8	23.32	20.50	47.03	0.110
Expenditure								
Stratum 1	17.59	6.42	−563.36	9.6	8.52	7.00	64.84	0.087
Stratum 2	15.04	7.60	−18.60	8.2	11.79	10.08	63.49	0.092
Stratum 3	13.80	8.61	+228.33	7.5	14.55	12.53	60.86	0.098
Stratum 4	12.90	9.94	+528.29	7.0	17.97	15.27	59.04	0.103
Stratum 5	40.67	67.43	+1,374.39	5.5	38.66	34.81	40.37	0.132

Source: Based on Pinstrup-Andersen et al., "Impact of Changes in Income and Food Prices on Food Consumption by Low-Income Households in Urban Khartoum with Emphasis on the Effect of Changes in Wheat-Bread Points" (International Food Policy Research Institute, Washington, D.C., 1983, mimeographed), Tables 1-11.

[a]Stratum 1 consumes below 80 percent of requirements; stratum 2, 80-100 percent; stratum 3, 100-120 percent; and stratum 4, above 120 percent.

PRCE = price of millet for Northern and Southern Darfur, and price of sorghum for Northern Kordofan, and

β_0, β_1, β_2, β_3, and β_4 are parameters to be estimated.

Each equation is related to per capita expenditure, household size, and price of main cereal crop. The equations were estimated using the 1978-80 data from the western provinces. The parameter estimates and associated t-statistics are reported in Table 56. Both the linear and quadratic terms of income are statistically significant. The signs suggest that income has a positive but diminishing effect on calorie consumption. Household-size signs are negative but significant only in the Darfur sample. The signs are consistent with the observation that households with comparable incomes but larger families consume fewer calories on average. The price of millet has a significant inverse effect on calorie consumption, reflecting its importance in the diets of the western provinces.

Elasticity estimates evaluated at sample means are given in Table 57. Calorie income elasticities range between 0.36 and 0.58. The elasticities imply that a 1.0 percent increase in per capita expenditure translates on average into an increase in calorie consumption between 0.36 and 0.58 percent. An increase in the price of millet has the opposite effect. A 1.0 percent increase in the price results on average in a drop in calories of 0.29-0.36 percent. If one accepts the inverse relation hypotheses (for example, Pinstrup-Andersen and Caicedo 1978; Timmer and Alderman 1979), these responses would be higher among poor households.

Table 56—Parameter estimates for calorie demand, by province

Province	Independent Variables[a]				Constant	$\bar{R}^2$	F
	lnPCEXP	lnPCEXP[2]	HHSZ	PRCE			
Northern Darfur	1.16 (3.12)	-0.08 (-2.05)	-0.05 (-5.57)	-3.84 (-3.93)	4.79 (5.54)	0.70	53.85
Southern Darfur	1.03 (4.07)	-0.05 (-1.91)	-0.03 (-4.97)	-2.27 (-3.12)	4.45 (7.49)	0.65	97.53
Northern Kordofan	1.44 (2.61)	-0.09 (-1.49)	-0.01 (-1.18)	-2.97 (-2.23)	3.52 (2.79)	0.56	43.00

Source: Based on data tape from the Ministry of Finance and Economic Planning, Department of Statistics, Khartoum.

Note: The figures in parentheses are t-statistics.

[a]Definitions of variables:

lnPCEXP = natural log of annual per capita expenditure;
lnPCEXP[2] = square term of lnPCEXP;
HHSZ = household size;
PRCE = price of millet for Northern and Southern Darfur, and price of sorghum for Northern Kordofan.

Table 57—Elasticity estimates for calorie consumption, by province

Province	Expenditure Elasticity	Size Elasticity	Price Elasticity
Northern Darfur	0.36	-0.29	-0.36
Southern Darfur	0.55	-0.21	-0.29
Northern Kordofan	0.58	a	-0.29

Source: Yisehac Yohannes, "Food Consumption Patterns in Western Sudan, 1978-80," Famine and Food Policy Discussion Paper 1 (International Food Policy Research Institute, Washington, D.C., 1990, mimeographed).

[a]Estimated parameter is not significant.

The observed empirical food and calorie demand behavior are largely comparable with studies in other low-income countries (Waterfield 1985; Pinstrup-Andersen 1985; Alderman 1986; Svedberg 1987). Low-income households spend a large share of their income on food. Income elasticities for food decline with income level. Low-income households are also sensitive to price changes. Food price changes cause more consumption adjustment among the poor because of their large food share and income elasticity. In other words, the burden of adjustment falls heavily on the low-income households in a period of food scarcity. Calorie elasticities also appear to fall with rising income. Svedberg's (1987) review of literature on microlevel studies on Africa highlights these relationships. Moreover, it stresses that calorie deficiency is a more serious problem and tends to be more unstable in villages located in unimodal and semi-arid zones. Infants and small children are the most at risk when it comes to malnutrition or undernutrition.

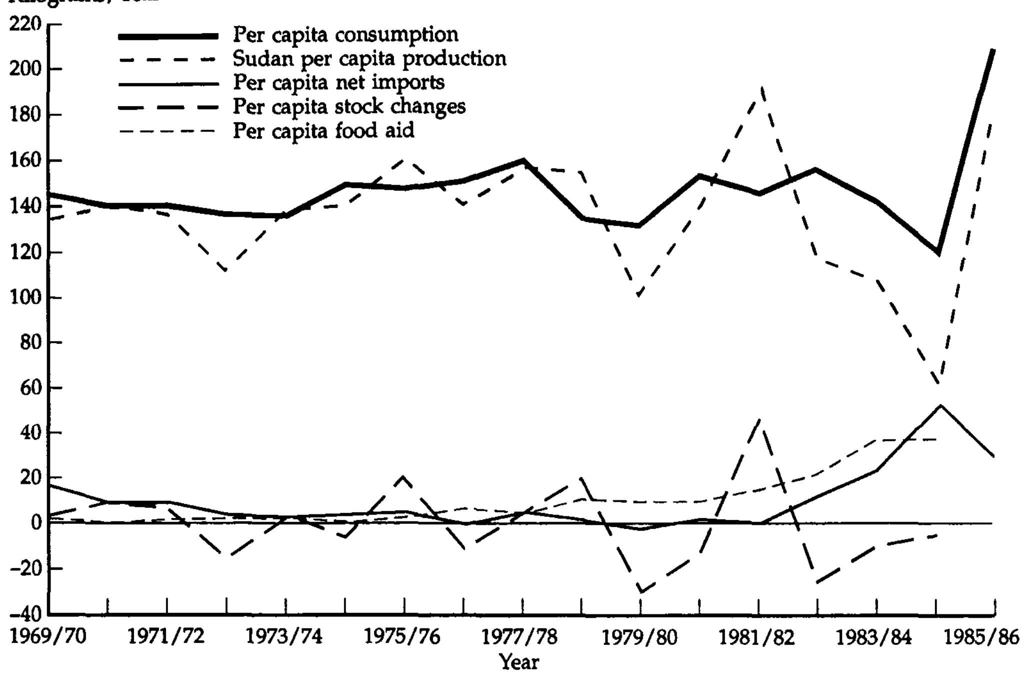
Decline in Food Availability

The absence of time-series data poses an information constraint to studying disaggregated Sudanese food consumption patterns over time. The best that may be done is to use an aggregate measure of food availability from food-balance-sheet estimates. Available food consumption estimates are derived from the aggregation of net domestic production available less net trade and net stock changes. These estimates in general set the upper bounds to actual consumption levels. FAO-based estimates are used here to examine the behavior of aggregate food consumption over time.

Cereal-food availability in Sudan is much determined by domestic staple food production (Figure 11). Domestic food production contributes on average 90 percent of total cereal consumption. There are, of course, marked variations among the

Figure 11—Per capita food consumption in Sudan, 1969/70–1985/86

Kilograms/Year



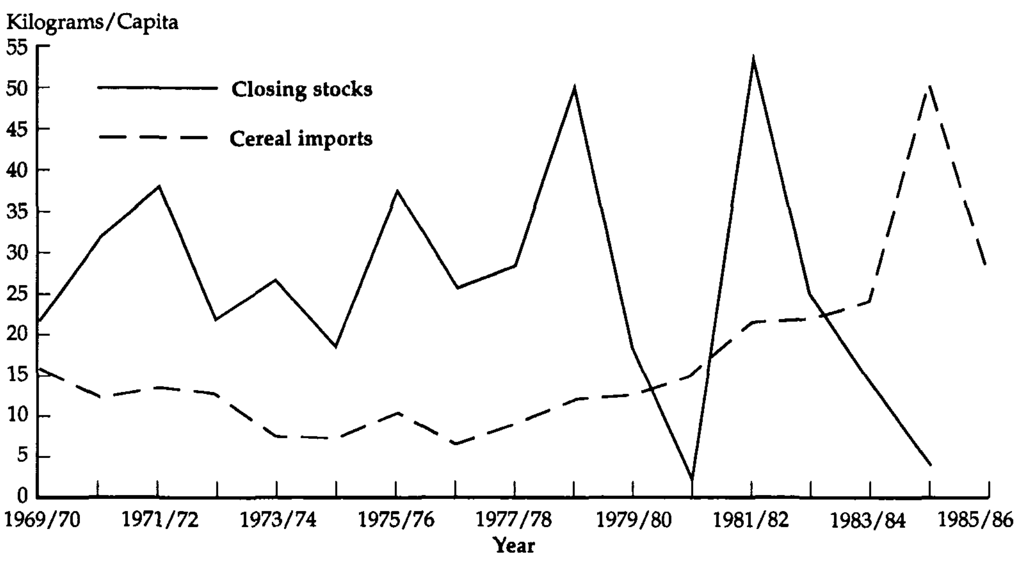
Sources: Compiled and computed from Sudan, Ministry of Agriculture and Natural Resources, *Yearbook of Agricultural Statistics* (Khartoum: MANR, 1977 and 1984); *Current Agricultural Statistics*, vol. 1, no. 4 (Khartoum: MANR, 1984); *Agricultural Situation and Outlook, Annual Report, 1984/1985* (Khartoum: MANR, 1985); and *Agricultural Situation and Outlook, Annual Report, 1986/87* (Khartoum: MANR, 1987); Food and Agriculture Organization of the United Nations, Office for Special Relief Operations, *Democratic Republic of Sudan, Report of the FAO/WFP Multidonor Mission, Assessment of the Food and Agricultural Situation*, OSRO Report 02/85/E (Rome: FAO, 1985); *Agricultural Trade Yearbook* (Rome: FAO, various issues); *Food Aid in Figures* (Rome: FAO, various issues); and "Food Supply Utilization Data Tape for Sudan," FAO, Rome, 1984.

individual cereal crops. Millet, the preferred crop in the west, is consumed solely from domestic production. The same applies to sorghum, which is largely consumed in the central, eastern, and southern regions. In fact, the nation registered a surplus production of sorghum in the late 1970s and 1980s and managed to export or build reserve stocks or both. The relative contribution of domestic production to wheat consumption is much lower, averaging 39 percent in the 1980s. Yet wheat is central to the policy debate in Sudan because of its relative preference among the urban population in greater Khartoum and other urban areas.

Relative contributions of imports and domestic stocks play a minor role in annual millet and sorghum availability. Years of large production shortfalls like 1982-84 are exceptions. Production as a share of consumption fell to a low 75 percent in 1984. To cope with the shortages, the government adopted a mix of measures, such as banning export of sorghum, drawing down reserve stocks, and appealing for outside support, which came largely in the form of grants and concessionary imports. In fact, the dwindling domestic production of wheat in the 1980s was made up largely from increased concessionary imports, which averaged 88 percent in the period between 1982 and 1986. These components are likely to remain important sources for the government to fall back on in periods of poor harvests.

Moreover, while Sudan traditionally faces a problem of extreme fluctuations in stocks, there also seem to have been increases in these fluctuations in the 1980s (Figure 12). (It should be noted that official stock figures are not all comprehen-

Figure 12—Per capita stocks available and per capita cereal imports in Sudan, 1969/70-1985/86



Sources: Compiled and computed from Food and Agriculture Organization of the United Nations, *Trade Yearbook* (Rome: various issues); FAO, Office for Special Relief Operations, *Democratic Republic of Sudan, Report of the FAO/WFP Multidonor Mission, Assessment of the Food and Agricultural Situation*, OSRO Report 02/85/E (Rome: FAO, 1985); and "Food Supply Utilization Data Tape for Sudan," FAO, Rome, 1985.

sive.) In view of the increased production fluctuations, the policies for stockholding and trading have certainly become more complex, and management of trade and stocks has become a much larger issue in terms of volume, fiscal costs, foreign exchange implications, and national human welfare.

Food availability per capita declined notably between 1970 and 1986. The annual growth rate was a significant −1.4 percent, largely reflecting the low growth in production relative to population. The trend diminishes (−0.7 percent) when the effect of the 1984 drought is controlled for, which evidences the strong adversity of the drought-production effect on cereal consumption. Average per capita cereal consumption dropped from a high of 100 kilograms in 1976 to 78 kilograms in 1983 and to 51 kilograms in 1984. The years 1985 and 1986 witnessed marked recovery but not to the magnitude of the prefamine level.

Incidence of the 1984-85 Famine

Aggregate declines in per capita consumption may not be accompanied by proportional drops across socioeconomic groups. In fact, the evidence shown above suggests that demand responses are varied. Of course, one needs a disaggregated demand matrix to trace the effects of, say, the 1984 drought on food and nutrient consumption across income groups. Such estimates should also preferably be reflective of behavior during the adjustment period. No such empirical estimates exist to assess drought-induced hunger effects.

Nevertheless, the demand estimates based on 1978-80 data could be used to approximate the hunger effects. Suppose the hunger indicator is calorie consumption below a certain level. The effect of change in rainfall on calorie consumption can be approximated through a recursive relationship of rainfall to production to calorie/price and calorie/income.[6] For example, the effect of a 10 percent change in rainfall in western Sudan translates into an average 3.5 percent reduction in calorie consumption. Note that these values are on the lower bounds, since the calorie elasticities are lower in the long run than in the short run.

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[6]These relations can be depicted for

$$\begin{aligned}
\text{price effect} &= \eta_{CRP} = \eta_{CP} \cdot \eta_{PQ} \cdot \eta_{QR}, \\
\text{income effect} &= \eta_{CRI} = \eta_{CY} \cdot \eta_{YQ} \cdot \eta_{QR}, \text{ and} \\
\text{total effect} &= \eta_{CR} = \eta_{CRP} + \eta_{CRI},
\end{aligned}$$

where

η_{CR} = calorie elasticity with respect to rainfall index (P = price effect, I = income effect),

η_{CP} = calorie elasticity with respect to price,

η_{PQ} = price elasticity with respect to production,

η_{QR} = output elasticity with respect to rainfall index,

η_{CY} = calorie elasticity with respect to income, and

η_{YQ} = income response with respect to cereal production (it is assumed that cereal-based income accounts directly and indirectly for nearly 80 percent of rural household income).

Nutrition-based sample surveys were also carried out widely in western Sudan in 1985 and 1986. These surveys were based on anthropometric measures of change in weight relative to height of children under five years old. The measures were compared with standard reference groups in order to identify groups that would qualify for food distribution and supplementary feedings and to monitor the nutritional effects of severe food shortages during the droughts. Examination of these results provides an additional dimension of the extent to which the droughts affected the population.

The OXFAM-UNICEF nutritional surveillance project, which was implemented in collaboration with the regional governments of Kordofan and Darfur, presents a more complete and consistent picture of the situation in 1985 and early 1986 (Table 58). By early 1985, about 13 percent of the children in Northern Kordofan were malnourished, that is, under 80 percent of the WHO/NCHS standard. The proportion peaked at 25 percent in mid-1985 and then dropped to 11 percent during the 1985 harvest. The situation markedly improved by early 1986 when it reached 7.5 percent. Within Northern Kordofan, the children in Bara and Sodari and north of Um Ruwaba district were relatively more malnourished, that is, those in the northern arid region were severely at risk.

The link between price change and child malnutrition is depicted in Figure 13. The dramatic deterioration of purchasing power caused by unfavorable changes in terms of trade was translated into increased incidence of severe child malnutrition in Kordofan. The market strongly affected the poor, and children in particular.

The price effects of the 1984 drought were also transmitted to the urban population despite numerous government interventions with the subsidy and rationing systems. The urban poor spent 65 percent of their total budget on food. The bottom 20 percent, in terms of per capita expenditure, tend to be deficient in food energy even in normal years such as 1979, when a food-expenditure survey was made in urban Khartoum (Pinstrup-Andersen et al. 1983). The price elasticity of cereals and bread among these poor sections of the urban population ranges from about −0.7 to −0.8, that is, a 1.0 percent increase in price reduces consumption by 0.7 percent. Households in upper-income groups respond much less to price changes for staple foods. Their price elasticity for cereals was estimated at −0.29 and for bread at −0.22 (Table 53).

A drastic decline in food availability in rural areas and the related movements of people into urban areas have probably led to a major decline in real wages and employment for those who were already urban residents and dependent on employment in service jobs at the lowest income brackets. This is to say that the food production crisis has probably been transmitted into urban areas not only via its widespread price effects but also through its effects on urban labor markets. Certainly the massive influx of drought victims into the urban and peri-urban areas should have contributed to increased inequality of income in the 1980s.

Nutritional Situation after the 1984-85 Famine

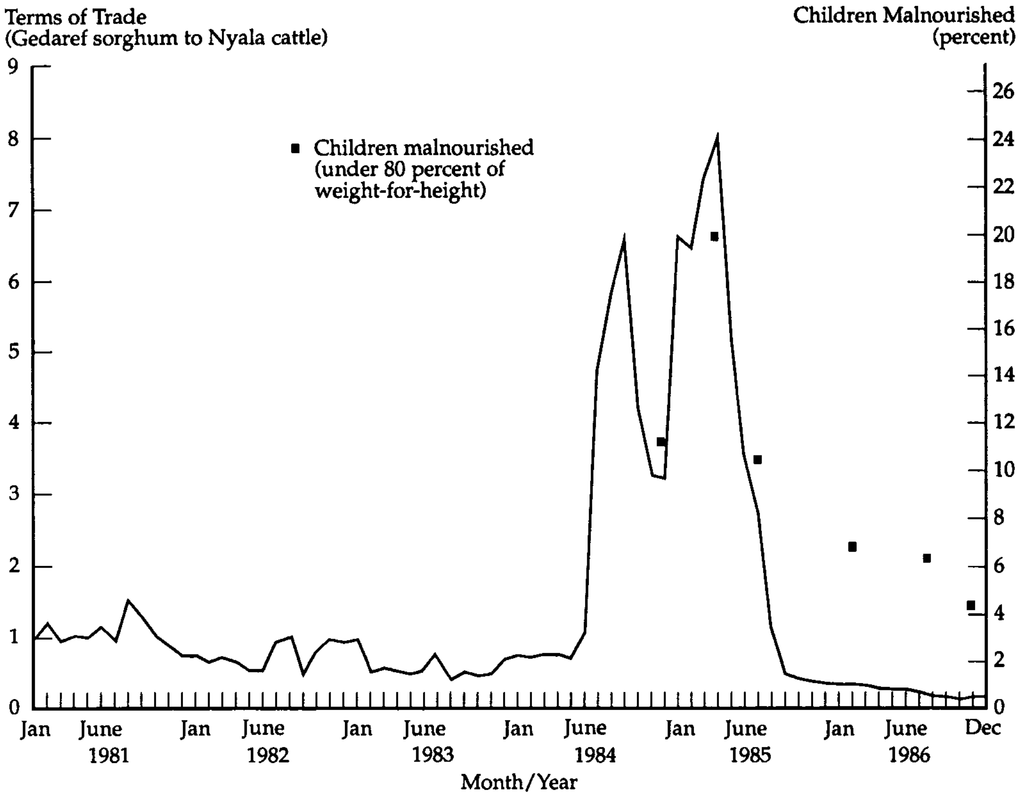
The 1984-85 famine ended with the coming of a good crop year in 1985. Improved food-aid distribution partly alleviated the situation in western Sudan in the second half of 1985. What was the nutritional situation after the famine?

Table 58—Proportion of children below 80 percent and 70 percent of standard weight-for-height among sedentary population in Kordofan, 1985/86

Site	February/March 1985			May/June 1985			September/October 1985			March/April 1986		
	Sample Mean	Under 80 Percent	Under 70 Percent	Sample Mean	Under 80 Percent	Under 70 Percent	Sample Mean	Under 80 Percent	Under 70 Percent	Sample Mean	Under 80 Percent	Under 70 Percent
						(percent of children)						
Kordofan Region	89.0	11.9	0.8	86.6	19.7	2.6	89.2	10.4	0.9	90.7	6.9	0.7
Northern Kordofan Province	88.7	13.1	1.1	84.7	25.2	3.4	89.1	11.0	1.2	90.0	7.5	0.7
Southern Kordofan Province	89.3	10.2	0.4	89.4	11.5	1.3	89.5	9.5	0.5	91.4	6.0	0.7

Sources: OXFAM-UNICEF and Kordofan Regional Government, "A Report on the Nutritional Status of 1,888 Children in Kordofan, February/March 1985"; "The Nutritional Status of Children in Kordofan, May/June 1985"; "The Nutritional Status of 4,575 Children in Kordofan Region, September/October, 1985"; and "The Nutritional Status of 3,183 Children in Kordofan Region, March 1986" (mimeographed)..

Figure 13— Seasonal cereal-livestock terms of trade and child malnutrition, January 1981-December 1986



Sources: Computed from price series data compiled from Sudan, Ministry of Agriculture and Natural Resources, *Agricultural Prices in Sudan: A Historical Review and Analysis, 1970–1984* (Khartoum: MANR, 1985); *Agricultural Situation and Outlook, Annual Report, 1984/85* (Khartoum: MANR, 1985); *Agricultural Situation and Outlook, Annual Report, 1986/87* (Khartoum: MANR, 1987); Sudan, Ministry of Health and Social Welfare, Sudan Emergency and Recovery Information and Surveillance System (SERISS) data tapes, 1986 and 1987.

Sudan's 1986-87 nutritional status survey (the largest in Sub-Saharan Africa) provides a data base to pursue this question.[7] It is used here to describe the pattern and causes of child malnutrition.

The October/November 1986 survey results show that 35 percent of children under five years of age were stunted (height-for-age), 42 percent were underweight (weight-for-age), and 16 percent were wasted (weight-for-height), using less than −2 standard deviations of Z-scores for respective measures (Table 59 and Figure 14). The seasonality effect was much stronger for the short-term indicator (weight-for-height), where the after-harvest, food-rich situation improved the nutritional situation in January/March 1987.

[7]For more details on survey design and sampling procedures, see Sudan, Ministry of Health and Social Welfare 1986a.

Table 59—Proportion of children under five years of age with below −2 Z-scores for standard indicators, 1986/87

Province/ Location	Weight-for-Height			Weight-for-Age			Height-for-Age		
	October-November 1986	January-March 1987	May-July 1987	October-November 1986	January-March 1987	May-July 1987	October-November 1986	January-March 1987	May-July 1987
	(percent of children)								
Province									
Khartoum	0.21	0.11	0.10	0.35	0.29	0.27	0.21	0.23	0.21
Northern	0.15	0.06	0.17	0.29	0.18	0.34	0.17	0.18	0.25
Nile	0.18	0.07	0.14	0.39	0.30	0.34	0.29	0.30	0.25
Red Sea	0.27	0.06	0.09	0.63	0.43	0.36	0.53	0.54	0.39
Kassala	0.14	0.07	0.10	0.43	0.36	0.45	0.37	0.40	0.45
Blue Nile	0.14	0.07	0.14	0.42	0.40	0.47	0.34	0.39	0.39
Gezira	0.09	0.02	0.09	0.46	0.33	0.38	0.47	0.41	0.32
White Nile	0.13	0.07	0.14	0.43	0.34	0.42	0.38	0.36	0.35
Northern Kordofan	0.11	0.08	0.13	0.36	0.34	0.40	0.34	0.35	0.33
Southern Kordofan	0.09	0.08	0.15	0.39	0.32	0.36	0.36	0.33	0.27
Northern Darfur	0.21	0.11	0.14	0.47	0.33	0.34	0.37	0.29	0.25
Southern Darfur	0.20	0.14	0.12	0.43	0.34	0.35	0.33	0.26	0.30
Location									
Urban	0.14	0.06	0.09	0.31	0.22	0.26	0.22	0.22	0.22
Rural	0.16	0.09	0.13	0.45	0.36	0.40	0.38	0.37	0.34
Nomad	0.17	0.06	0.14	0.52	0.35	0.45	0.47	0.39	0.34
Sudan	0.16	0.08	0.12	0.42	0.33	0.37	0.35	0.33	0.31

Source: Computed from Sudan, Ministry of Health and Social Welfare, Nutrition Division, *Sudan Emergency and Recovery Information and Surveillance System (SERISS)*, Operational Manual (Khartoum: MANR, 1986).

Figure 14—Relative distribution of sample children, by type and level of anthropometric status indicator, Sudan, 1986

Height-for-Age Z-Scores

Midpoint	Frequency (percent)
−4.25	2.30
−3.75	4.30
−3.25	6.65
−2.75	9.45
−2.25	11.89
−1.75	13.65
−1.25	14.20
−0.75	12.07
−0.25	9.93
0.25	6.67
0.75	4.03
1.25	2.35
1.75	1.12
2.25	0.69
3.25	0.23

Frequency (percent)

Weight-for-Age Z-Scores

Midpoint	Frequency (percent)
−4.25	1.58
−3.75	3.54
−3.25	7.32
−2.75	12.21
−2.25	16.72
−1.75	17.37
−1.25	15.41
−0.75	10.36
−0.25	6.74
0.25	4.33
0.75	2.18
1.25	1.20
1.75	0.54
2.25	0.28

Frequency (percent)

Weight-for-Height Z-Scores

Midpoint	Frequency (percent)
−4.25	0.22
−3.75	0.51
−3.25	1.36
−2.75	4.05
−2.25	9.30
−1.75	16.86
−1.25	20.82
−0.75	18.27
−0.25	12.54
0.25	8.36
0.75	4.34
1.25	1.75
1.75	0.87
2.25	0.44

Frequency (percent)

The prevalence of malnutrition was higher in rural areas, particularly among the nomads, but the levels were also high for urban areas. Large regional variations were also observed. The worst areas were Red Sea, Kassala, and Gezira Provinces. Clearly, the country had a persistent food-security problem with significant variations across locations (urban/rural), provinces, and seasons (see also Maxwell 1989). Urban areas themselves are not free of sizable seasonality effects (see weight-for-height, Table 59).

Causes of Malnutrition

The large regional coverage of the Sudan Emergency and Recovery Information and Surveillance System (SERISS) surveys of children (Sudan, Ministry of Health and Social Welfare 1986b and 1987) and the presence of community-related variables allow some unique analysis. Community-level data are available only for the round 3 (January/March 1987) and round 4 (May/July 1987) surveys. These two rounds are used in this study, pooling about 30,000 children for a two-stage regression analysis. The model explaining the nutritional status of preschool children (weight-for-age) comprises the following exogenous variables:

- child demographics (SEX, KIDAGE, KIDAGESQ);
- household demographics (SIZE, SIZESQ, TOTKIDS);
- parents' sociodemographics, including human capital (MOTHAGE, MAOCCUP, MOTHLT, FATHLT);
- household food-consumption level (LGRPRE);
- meal frequency (MEALLT3);
- child health, short term (DIARPRE); and
- community health environment (INFECT, HLTHSERV).

To account for endogeneity of food consumption (LGRPRE) and short-term health status (DIARPRE), both of these critical variables are instrumentalized. Variables related to price, agricultural technology, and community income enter the instrumentalization of the consumption variable. Particular attention is given to including availability of piped water in villages and prevalence of irrigated agriculture as variables for diarrhea prediction.

The main hypotheses underlying the model specification are that

- improved household (parents) human capital improves nutrition (MOTHLT, FATHLT);
- higher levels of food consumption per capita and higher meal frequency in the household improve nutrition (LGRPRE, MEALLT3);
- children who currently have diarrhea (DIARPRE) are worse off, especially in the short term, but also in the long term to the extent that current diarrhea is a symptom of a persistent problem;
- a poor health environment and limited access to health services contribute to a worse nutritional situation (INFECT, HLTHSERV); and
- an improved piped-water supply improves nutrition via reduced diarrhea (PIPEWTR).

Regression estimates for nutritional status indicators are used to test these hypotheses, conditional on a set of child and household demographic characteristics. In addition, there are tests for seasonality (ROUND3) and effects of residence in predominantly mechanized (MECHY) or irrigated (IRRGY) areas, compared with traditional rainfed agriculture entered through the instrumentalization of the health and food consumption variables (see list of variables in Table 60).

The results largely substantiate these hypotheses and give additional interesting insights (Tables 61 and 62). The following are the highlights of the findings:

1. Parents' education, especially mother's education in the long term, has a positive impact on child nutrition. In fact, mother's literacy increases child nutrition, holding other things constant, by more than twice as much as father's literacy.

2. The direct effect of household per capita cereal consumption on children's nutrition is small but statistically highly significant. But in a period of famine when there is a large reduction in the consumption level, the impact could be sizable. Millet price plays an important role in grain consumption (Table 61) and thus affects child nutrition in the expected way.

3. A large marginal effect is shown by the meal frequency variable, which separates households that had less than three meals a day at the time of the survey. This can be viewed as an indicator of severe absolute poverty. Fourteen percent of these children from such households in the sample who registered, holding other things constant, were one-quarter Z-score below the others.

Table 60—Determinants of child nutrition: list of variables

Variable	Variable Definition	Mean	Standard Deviation
WAZ	Weight-for-age	-1.50	1.19
SEX	Sex (male = 1)	0.51	0.50
KIDAGE	Age of child in months	29.97	17.62
KIDAGESQ	Age of child squared	1,209.04	1,099.05
METHAGE	Child birth certificate (yes = 1)	0.30	0.46
MOTHAGE	Mother's age in years	29.46	6.14
MSTATUS	Mother's marital status (1 if married)	0.97	0.18
MAOCCUP	Mother's occupation	0.22	0.42
SIZE	Household size	7.21	3.09
SIZESQ	Household size squared	61.02	66.79
TOTKIDS	Number of children under five years	1.82	0.66
LNGRCAP	Log of grain consumption per capita	5.95	0.43
MEALLT3	Less than three meals per day (1 if true)	0.14	0.35
MOTHLT	Mother's literacy (yes = 1)	0.21	0.41
FATHLT	ather's literacy (yes = 1)	0.46	0.50
DIARNOW	Diarrhea at present (yes = 1)	0.20	0.40
INFECT	Prevalence of infectious diseases (scaled 0-5)	3.07	1.31
HLTHSERV	Distance to health center or hospital (scaled 1-4)	2.53	1.32
PIPEWTR	Piped water availability (yes = 1)	0.30	0.46
ASSCMN	Community participation (yes = 1)	0.33	0.47
MECHY	Mechanized rainfed agriculture area (yes = 1)	0.11	0.31
IRRGY	Mechanized irrigated agriculture area (yes = 1)	0.26	0.44
ROUND3	Season representative survey round 3 (1 if January-March 1987)	0.50	0.50
IMIGNEW	Number of immigrants	1.47	6.21
EXMIGNEW	Number of ex-migrants	0.51	2.51
DURAPR	Village average price of *dura*	156.20	30.78
DEPRATIO	Dependency ratio	0.22	0.12
DIARPRE	Predicted DIARNOW	0.21	0.03
LGRPRE	Predicted LNGRCAP	6.04	0.12

Table 61—Model analysis on determinants of nutrition: predicted grain consumption

Variable	Variable Definition	Parameter Estimate	t-Value
EXMIGNEW	Number of ex-migrants	-3.38204	-9.186
SIZESQ	Household size squared	0.38003	11.962
MSTATUS	Mother's marital status (1 if married)	-11.25482	-2.142
DURAPR	Village average price of *dura*	-0.27318	-8.656
IRRGY	Mechanized irrgated agriculture area (yes = 1)	-29.45766	-13.195
IMIGNEW	Number of immigrants	-0.14535	-0.978
MECHY	Mechanized rainfed agriculture area (yes = 1)	-30.53279	-9.729
MOTHLT	Mother's literacy (yes = 1)	-46.51363	-17.854
ASSCMN	Community participation (yes = 1)	-10.45667	-4.967
DEPRATIO	Dependency ratio	45.38720	4.545
FATHLT	ather's literacy (yes = 1)	-11.18718	-5.270
SIZE	Household size	-13.77757	-17.333
Constant		571.55591	63.254
$\bar{R}^2 = 0.072$			
Degrees of freedom:	29,960		
F = 193.8			

Table 62—Model analysis on determinants of nutrition: predicted child health

Variable	Variable Definition	Parameter Estimate	t-Value
MOTHLT	Mother's literacy (yes = 1)	-0.02304	-3.460
MSTATUS	Mother's marital status (1 if married)	0.03353	2.556
IMIGNEW	Number of immigrants	2.062222E-03	5.603
IRRGY	Mechanized irrigated agriculture area (yes = 1)	8.472184E-03	1.517
PIPEWTR	Piped-water availability (yes = 1)	-0.04651	-8.130
FATHLT	Father's literacy (yes = 1)	-0.01052	-1.982
Constant		0.19128	14.926
$\bar{R}^2 = 0.006$			
Degrees of freedom:	29,791		
F = 28.8			

4. Besides the food-shortage indicator of less than three meals a day, the diarrhea variable is the most powerful for child nutrition. Piped water reduces diarrhea substantially, but irrigation was not found to increase it (Table 63).

5. A better community health and sanitation environment would make a difference for child nutritional status, as indicated by the piped water working through reduced diarrhea to reduce malnutrition. A closer health service facility also contributes to improved nutritional status.

6. The agricultural production environment does not have a significant impact on the nutritional indicator directly. However, households' food consumption worsens in both mechanized rainfed and irrigated agricultural environments, and this does translate into a worse nutritional outcome (see Table 61).

Table 63—Model analysis on determinants of child nutrition status

Variable	Variable Definition	Parameter Estimate	t-Value
DIARPRE	Predicted DIARNOW	-1.53466	-5.527
SEX	Sex (male = 1)	-0.03424	-2.699
MEALLT3	Less than three meals per day (1 if true)	-0.27623	-15.010
ROUND3	Season representative survey round 3 (1 if January-March 1987)	0.12222	9.381
MOTHAGE	Mother's age in years	5.307271E-03	4.588
MAOCCUP	Mother's occupation	0.05553	3.527
INFECT	Prevalence of infectious diseases (scaled 0-5)	5.697872E-03	1.150
KIDAGESQ	Age of child squared	1.290052E-03	56.539
SIZESQ	Household size squared	-1.10861E-03	-4.628
METHAGE	Child birth certificate (yes = 1)	0.16518	10.276
HLTHSERV	Distance to health center or hospital (scaled 1-4)	-0.02522	-4.695
FATHLT	Father's literacy (yes = 1)	0.11184	7.154
MOTHLT	Mother's literacy (yes = 1)	0.28782	10.784
LGRPRE	Predicted LNGRCAP	0.87774	6.712
SIZE	Household size	0.04251	6.184
KIDAGE	Age of child in months	-0.09098	-63.977
Constant		-5.87219	-7.128
$\bar{R}^2 = 0.159$			
Degrees of freedom:	28,709		
F = 340.8			

Note: The consumption and health variables are predicted.

Important policy conclusions emerge from these findings: (1) The acute food shortage problem remains a major concern in a significant proportion of households. Even in a good year, as in 1986/87, the hunger problem was widespread and the relationship to child nutrition was strong. Creation of effective demand through employment creation and a host of measures to generate and transfer purchasing power to the poor is necessary; (2) improvement in community health and sanitation environment goes a long way toward nutritional improvement. The short-term diarrhea problem needs to be addressed in this context; and (3) rapid improvement in human capital, especially formal education, promises high returns in nutritional improvement through both the productivity and income effects.

Public action is called for in all three of these areas. Although the effects are partly long term, this action needs more urgent attention now, since household-response capabilities have been exhausted and community services eroded by the famines of the 1980s.

7

PAST POLICIES AND PROGRAMS FOR COPING WITH DROUGHT AND FAMINE

Sudan's experience in the 1980s has demonstrated the strong link between drought and famine in an environment where the agricultural resource base is poor, asset and income levels are low and variable, and public preparedness is lacking. The absence of public policy and institutional capacity to predict, prepare, and intervene was notable in view of the country's long history of drought-related famines and its past record of successful application of legislated famine prevention policy (famine codes). The lessons of 1984-85 appear to center on the public realization of the need to improve the production and income base of the rural population; to moderate fluctuations of production, prices, and income; and to establish a permanent institution to deal with relief and rehabilitation. This study underlines the key policy choices and views development, relief, and rehabilitation as integral components of a broad framework of famine prevention and preparedness.

It is argued in this study that famine events in Sudan are very much the result of short-term policy failures and market imperfections arising in a difficult-to-manage agroclimatic environment, fostered by deficiencies in long-run economic strategies. As was argued at the outset, the drought-famine relationships need to be assessed in a broader economic-policy context. The short-term crisis events are to a large extent the result of long-term policy failures, especially those related to agriculture. Therefore, this chapter first presents an overview of the long-term policy environment. Next, attention is drawn to relief policies for famine prevention in Sudan earlier in this century. The conclusion of the analysis is that it is largely policy failure that makes drought the triggering factor for famines. Dealing with drought, however, poses a major challenge to policy.

Economic Plans and Programs without a Strategy

Following independence in 1956, Sudan continued its policy of promoting production for export in the high potential riverine lands of central Sudan. Irrigated agriculture continued to be organized along the structure set in the Gezira scheme in 1925, where the sole priority was cotton production. This approach continued with the nation's first Economic and Social Development Plan, which came into effect in 1961/62 for a period of 10 years (see Wohlmuth 1987 and D'Silva 1985 for a review).

Parallel to the expansion of irrigated agriculture, there was spontaneous growth in private mechanized farming in the dryland of Eastern and Central regions. The government established the Mechanized Farming Corporation in 1968 to streamline, regulate, and provide support for expansion of mechanized agriculture. Large-scale privately financed mechanized farming was considered an important and quick means of promoting agricultural production in a country where land was assumed to be abundant (Elhassan 1988).

The subsequent plan, which was set for a five-year period (1970/71-1974/75), continued the emphasis on irrigated and mechanized agriculture to accelerate cash- and food-crop production in high-potential areas. Agricultural policy took a more aggressive turn in 1973, when the government introduced an interim action program that modified the original plan. With high prospects and commitments for large inflows of capital from Arab countries that prospered from the oil boom of the mid-1970s, and with Sudan's assumed great potential to produce an exportable surplus to meet its food import needs, the government embarked on a drive—the "breadbasket strategy"—to promote agricultural production and agro-industrial products. Development expenditures allocated to these projects greatly increased from SD£42 million to SD£102 million in the single year between 1973/74 and 1974/75. Nearly two-thirds of the expenditures were foreign-financed, largely from Arab funds.

The drive for the breadbasket strategy got a further push in the following Six-Year Plan (1977/78-1982/83), when the desire to attain self-sufficiency in selected food crops, particularly in wheat and sorghum, was articulated. The government's Food Investment Strategy of 1977 set this goal and called for the infusion of large-scale private capital into mechanized farming. In addition, the Six-Year Plan aimed at enhancing the speed and capacity of the agricultural sector to increase production and expand the export base to meet food demands in the Arab world. The Arab Fund's Basic Program for Agricultural Development for 1976-1985 provided the basis for the evolution of the production structure. The program's goal was to make Sudan a major exporter of sugar, wheat, oilseed, meat, fruits, and vegetables (Adams and Howell 1979).

An important departure of the Six-Year Plan, compared with its predecessors, was its recognition of the importance of traditional smallholder agriculture and the call for a parallel development strategy that would continue development of irrigated and mechanized agriculture and stimulate traditional crop and livestock production. In practice, however, the process meant an infusion of projects to mechanize traditional agriculture and establishment of modern ranches and large agricultural cooperatives (Adams and Howell 1979). The policy, in effect, resulted in mechanization of some selected high-potential areas.

The Six-Year Plan was abandoned a year after its inception as the country's economic crisis deepened and its planned growth got off track and was unsustained. Economic growth, which registered rapid rates of increase in the mid-1970s, started to taper off in 1977. The economy declined at an annual rate of −1.6 percent in 1977, followed by −10.4 percent in 1978 (Table 64). The substantial inflow of capital from Arab countries peaked in 1974/75 and tapered off in the second half of the 1970s.

The government, constrained by low public savings, turned to borrowing from the Central Bank to finance its mounting deficits. Central Bank financing of the overall public deficit reached 97 percent in 1977/78. The growth rate of money supply surged from 19 percent in 1974/75 to 31 percent in 1978/79. The average

Table 64—Macroeconomic indicators for selected years, Sudan

Indicator	1973/74	1974/75	1977/78	1978/79	1980/81	1982/83	1984/85	1985/86
Growth rate of real GDP (percent/year)[a]	10.2	6.7	-1.6	-10.4	2.2	3.3	-14.4	9.3
Overall public deficit (percent of GDP)	1.1	4.4	5.2	9.4	13.2	7.9	15.9	12.7
Share of development expenditure (percent of GDP)	3.4	6.8	6.5	5.1	5.8	4.5	3.4	1.7
Growth rate (percent/year)								
Money supply (M2)	29	19	26	31	38	42	59	32
Inflation rate[b]	25	23	20	32	24	31	46	29
Index								
Real exports	100	102	75	66	69	75	55	38
Real imports	100	154	126	108	128	166	80	62
Real exchange rate[c]	100	109	123	141	132	74	106	n.a.

Sources: World Bank, *Sudan: Prospects for Rehabilitation of the Sudanese Economy*, vols. 1, 2, and 3 (Washington, D.C.: World Bank, 1985); World Bank, *Sudan: Problems of Economic Adjustment*, vols. 1, 2, and 3 (Washington, D.C.: World Bank, 1987); and Bank of Sudan, *Annual Report* (Khartoum: Bank of Sudan, 1980-86).

Note: n.a. means not available.

[a]GDP refers to real gross domestic product in 1981/82 prices.

[b]Based on simple average of cost-of-living indices for low- and high-income groups.

[c]Nominal exchange rate adjusted for different inflation rates between Sudan and the United States.

inflation rate rose from 23 percent to 32 percent over the same period, partly because of an easy monetary policy. Moreover, the economy failed to meet the excess demand that was partly fueled by the expansionary investment program and the lag in the supply response of new projects. Increases in petroleum and petroleum products prices also contributed to the increase in the general price level. The sluggish export performance, particularly of cotton, in the 1970s, coupled with rising import bills, precipitated large deficits in the trade balance. The nation's capacity to service its external debt obligations shrank in the face of its worsening capacity to raise foreign exchange either through trade or capital inflows. In the late 1970s the mounting disequilibria in both internal and external balances obliged the government to enter into a stabilization and adjustment program designed by the International Monetary Fund/International Bank for Reconstruction and Development.

This program, which started primarily as a stabilization scheme in 1978, expanded into a comprehensive Economic Recovery Program in 1980. The program goals were to accelerate agricultural production, especially export and import-substituting crops, close the budget deficits, cut the rising inflation rate, and improve the capacity to earn the foreign exchange to repay the mounting external public debts. A combination of fiscal, monetary, exchange-rate, price, trade-liberalization, and institutional-reform policies was instituted. The fiscal policy comprised measures to cut as well as to reprioritize government spending and to enhance revenue generation. Monetary measures involved setting targets for credit and money supply and limits to public borrowing as well as alignment of nominal interest rates with rising price levels. The exchange rates were set to be devalued and unified to encourage growth of tradable production sectors, especially those involved in the production of export commodities. Other policy measures included deregulation of prices and liberalization of trade to create an economic environment conducive to greater participation by the private sector. The government pursued these policies within the framework of a rolling three-year public-investment program.

An Agriculture Rehabilitation Program was integrated as a component of the economic recovery program. It placed a heavy emphasis on the country's capacity to generate foreign earnings through the export of cotton. This was to be achieved through the completion of ongoing viable projects, rehabilitation of existing production capacity, and improvement of the incentive and income-sharing arrangements of cotton producers in the irrigated schemes. The prime target was the irrigated subsector, which was assumed to yield quick economic returns. However, the program noted the high potential of the rainfed-agriculture sector to stimulate the economy and called for devising a strategy for the development of this sector.

The recovery program continued for seven years until 1985, when it was suspended by a new military government. It was replaced by the annual development plan for 1985. The abandonment of the recovery program was related to its failure to ameliorate the worsening economic situation of the country, which was accelerated by drought in 1984. Macroeconomic indicators for 1984/85, for instance, show that real GDP fell 14.4 percent, and the public deficit registered as 16 percent of GDP. The annual inflation rate reached 46 percent and thus contributed to an appreciation of the real exchange rate—changes in the nominal exchange rate did not translate into real devaluation, at least in 1984/85. The macroeconomic development and failure to implement comprehensive reform—including moving to a market-oriented exchange rate—have been identified as major underlying causes of the increased famine vulnerability of the Sudanese economy (Atabani 1991).

Views differ on the factors that contributed to the ineffectiveness of the recovery program (see Brown 1986 for a review). The donor community associates the poor performance with shifts in government priorities and adherence to partial programs and piecemeal measures. Such government behavior might have resulted from the debilitating effects of three years of continuous droughts, the so-called Islamization program (which included abolition of income taxes and interest rate charges), the war in the south, and concern for the political repercussions of some of the measures. Advocates of the more structural approach consider the policy package of the recovery program to have been irrelevant or insufficient to solve the deep economic crisis.

The civilian government that came to power in 1986 introduced the Four-Year Economic Salvation, Recovery, and Development Program, which, like previous economic development efforts, had the broad objective of achieving sustained economic growth and effectively boosting real per capita GDP. The agricultural sector's role was considered to be of prime importance—increased agricultural production would spearhead the growth process. The program also incorporated goals of income and wealth redistribution and food security for rural and urban populations. In contrast to the previous economic development plans, the 1986 program, drawn in the aftermath of the country's bitter experience with the 1984-85 famine that revealed its vulnerability, recognized the need not only for adequate food production but also for an operationally efficient food-distribution system.

Economic Deterioration and War

Successive governments have relied heavily on partial solutions and economy-wide controls to suppress excess aggregate demand. More important, the food and agricultural policies pursued in Sudan so far have concentrated on the irrigated agriculture subsector and large-scale mechanized farming to the neglect of traditional, smallholder agriculture.

This is all against the background of continued conflict and war. The country has been engaged in a protracted war since 1955, though there was a 10-year spell of peace from 1972 to 1983. As a result of the war, millions of rural people have been displaced and forced to migrate, leaving their homes and changing from producers to net receivers of food relief. Production has been disrupted and employment opportunities have diminished (there is no war machinery creating a short-term war boom).

Relief Policies and Responses

Sudanese records show that the country has a long history of recurrent famines. Except for the period between 1920 and 1956, public response to prevent and contain famines has been nonexistent. The rural population has had to depend largely on their own resources and coping strategies. Such capabilities, however, have been threatened in recent years, particularly in the aftermath of the 1984-85 famine, because of greatly reduced asset bases of the rural population and increased volatility of employment, income, and food prices in rural areas. Medium- and long-term programs aimed at durable solutions need to be initiated to reverse the present trends, stabilize the population of the affected areas, and create sustainable environments. Accordingly, a new approach is needed; yet, some lessons from Sudan's own past experience are worthy of remembrance.

Colonial Famine Policy

The colonial famine policy in Sudan was much influenced by the British experience gained in India. In India, detailed famine legislation had been drawn up during the second quarter of the last century. These famine codes focused on earlier identification of the risks of famine, the provision of employment and public work schemes for those who can work, and food distribution to those unable to work (Dréze 1988).

The British administration in Sudan induced the establishment of a similar approach to famine policies. National famine regulations were actually drawn up after the First World War (1920) and guided government actions in cases of famine during the next three decades (Shepherd 1988). The regulations embodied three cardinal guiding principles: the government should respond promptly to provide relief to those in need; relief should be in the form of provision of employment to those able to work; and free food should be distributed to those unable to work.

The 1920 famine codes outlined the process of discovery, preparedness, and intervention in times of threat or actual famine. The components of governmental reaction to famine are very similar to today's components of a disaster relief policy. The main components were (1) discovery of threat of famine through a system of intelligence gathering including personal inspection; (2) preliminary measures of preparation, which included, among others, validation of information, selection of programs and sites for relief work, and tests to see if there was actual famine. The tests involved provision of public works at low wages and under hard conditions; (3) immediate implementation of a relief program, as soon as the existence of famine was declared, that included the provision of work for the able-bodied and free food for those unable to work; and (4) detailed inspection of relief work and assessment of the effectiveness of the relief program.

The famine regulations, which were in effect between 1920 and 1956, were instrumental in preventing major famines. They were applied "almost fifty times in different areas of Sudan" during this period (Pearson 1986). Actions taken to prevent famine became routine features of famine administration (Shepherd 1988).

Food Aid and Relief Management, 1984-88

Between the mid-1950s and early 1980s, there were no special institutions that handled antifamine work. Even though no major food crisis developed in these years, the Sahel drought of 1968-73 had a localized impact, particularly in the west. Because of the abandonment of the earlier relief regulations without substitution of a viable national policy to prevent famine, the rural population had to resort to their traditional coping mechanisms. The government's failure to maintain and further improve the earlier famine-prevention policies proved very burdensome for the rural population. The droughts of 1982-84 and the great famine of 1984-85 revealed the limits to the ability of the rural population to subsist on its own.

The onset of the 1984-85 famine was noted as early as 1983. People moved on a permanent basis from the drier areas of Northern Kordofan and Northern Darfur in 1983. The governors of the western and eastern provinces appealed to the central government in late 1983 and early 1984 to provide relief support. The government response was slow and ad hoc (banning of sorghum exports in March 1984, increase of area under sorghum cultivation in the irrigated areas, and shipment of 5,400 tons of sorghum to the west in April/May). The lack of sufficient response from the central government prompted the governor of Darfur to resign in April 1984. Except for some sorghum that reached western Sudan in late 1984, relief activity gathered momentum and peaked in May/June 1985—several months after the appeal by the governors for emergency support.

There were three principal waves of food aid to western Sudan in the 1980s in response to major crop and income failures. The first and major food-aid flow was initiated in 1984-86. Another crop failure was experienced in 1987, prompting a second relief flow in 1988. The good crop year of 1988 was followed by two consecutive years of bad harvests, which called for a third wave of food aid.

Kordofan received a total of 331,300 tons of cereal food aid in the 1984-86 period (Table 65). The flow of food aid dropped to 32,100 tons in 1986/87 but recovered to about 72,000 tons in 1988.

A series of administrative committees were established in Kordofan by the end of 1984. A high-level policymaking relief committee was established in August

Table 65—Delivery of relief food to Kordofan, 1985-88

Year	Commodity	Quantity	Government Share
		(1,000 metric tons)	(percent)
1985	Sorghum	195	11
1986	Sorghum	131	0
	Wheat and wheat flour	55	...
	Supplementary feeding	12	...
	Others	9	...
1987	Sorghum	32	37
1988	Sorghum	72	44

Source: Based on data from the Regional Food Aid Administration Office, El Obeid.

1984. It was responsible for setting up plans, strategies, and policies to mobilize resources and to guide and supervise relief work. Technical committees were set up at the regional and local levels to implement the 1984/85 relief operation. An office of Regional Food Aid Administration (RFAA) was created in August 1984 to administer food aid in collaboration with the technical committees.

The donor community took a leading role in relief operations in 1985/86. The Relief and Rehabilitation Commission, which had been created in mid-1985 (see Appendix), was not yet in a position to provide effective institutional support. Food delivery was undertaken largely by donors with assistance from foreign nongovernmental organizations (NGOs). In Kordofan, the NGOs operated within specific zones under the umbrella of RFAA and the technical committees. For example, CARE operated in Sodari, Bara, En Nahud, and El Obeid districts, Save the Children Fund/USA in Um Ruwaba district, and Sudan Aid in northern En Nahud.

This parallel structure was abandoned at the end of the 1984-86 relief operation. The RFAA office in Kordofan took responsibility for the distribution and management of relief work in 1988 (Buchanan-Smith 1990). The local technical committees were used as vehicles for delivery of relief food to the recipients. The donors monitored and supervised the relief work through a privately contracted firm.

Intraregional relief food allocation was largely based on assessment of area specific needs. For 1984/85, districts in Kordofan were ranked according to crop production record, scale of out-migration, anthropometric measures of nutritional status, and reported mortality rates. The RFAA office adopted 450 grams per person as a minimum full quota per day. Varying fractions of the full quota were then applied to the districts to reflect these rankings. A maximum allocation per family was set, based on the assumption that no family had more than six members.

For 1985/86 and 1986/87, the concept of a subsistence gap was applied as a measure of need. Districts were ranked according to the estimated percentage of the subsistence gap. Rural councils within specific districts were allocated a variation of the district-specific quota in accordance with their rankings. To determine its relief needs for 1987/88, Kordofan was divided into three crop-risk zones. Risk was defined in terms of the extent of expected crop failure. The full quota was then assigned to areas in the complete crop-failure zone. In effect, the methodology of food assessment in 1988 regressed as compared with the food-balance approach adopted in 1986 and 1987.

At the household level, allocation within specific target areas was based on the principle of equal distribution. That is, resident families within specific food-target areas were equally eligible for distribution. Priority was accorded to all who stayed in their place of residence during the operation, including those in towns. Except for a small share of the quota that was monetized, food was largely distributed free.

Food aid reached a high percentage of the rural population in the 1984-86 operation, but there were notable deficiencies. Food aid arrived at the villages at different points in time. In some of these villages the severity of the food shortage reached its peak in the months preceding the arrival of food aid (Table 66). When the waiting period was too long, a village would move en masse in search of work and relief. The poor timeliness was partly related to the fact that food allocated to the region was not delivered on schedule.

Food aid that was actually delivered was often much less than the planned, area-specific ration (Table 67). Two important factors explain such below-target delivery. First, food allocated to the region was not sufficient to meet the planned distribution. Second, there were considerable losses due to wastage and leakage. For example, combining the lower-than-target allocation and underweight factors, the total sorghum available for the May-October 1985 allocation was sufficient only for a 3.3-month allocation.

The original allocation plan of "equal per capita" was not observed. For example, there were significant intervillage variations in actual per capita distribution within the same district (Table 66). These variations were related to irregularities in the timing and frequency of food-aid flows across villages. In addition, there

Table 66—Relief food arrival time, amount distributed, and frequency in sample villages of Northern Kordofan, 1984/85

District/Village	Peak Hunger Period	Relief Food Arrival Time	Amount Distributed per Ration	Delivery Interval
	(month/year)	(month/year)	(kilograms/person)	(days)
Bara				
El Genena	September 1984	February 1985	9	30 – 45
Um Sereha	October 1984	February 1985	9	30 – 45
Um Sot	October 1984	February 1985	12	30 – 45
El Obeid				
Abu Khrais	November 1984	December 1984	4.5 – 6	30 – 40
El Liwab	December 1984	February 1985	4.6 – 6	30 – 40
El Tina	November 1984	May 1985	6	30 – 40
Um Ruwaba				
El Felia	October 1984	November 1984	3 – 6	30 – 90
Wed Eldeik	August 1984	October 1984	n.a.	n.a.

Source: International Food Policy Research Institute survey, 1989.
Note: n.a. means not available.

Table 67—Food aid targeted and received in districts of Northern Kordofan, May-October 1985

District	Target Delivery	Amount Received	Percent of Target Population
	(grams/capita/day)		
Sodari	450	213	21
Bara	400	364	15
En Nahud	400	180	67
El Obeid	350	288	91
Um Ruwaba	350	132	20

Sources: OXFAM-UNICEF and Kordofan Regional Government, "A Report on the Nutritional Status of 1,888 Children in Kordofan, February/March 1985"; "The Nutritional Status of Children in Kordofan, May/June 1985"; "The Nutritional Status of 4,575 Children in Kordofan Region, September/October, 1985"; and "The Nutritional Status of 3,183 Children in Kordofan Region, March 1986" (mimeographed).

was less adherence to the application of a uniform quota—the premium (such as malnutrition or migration) of getting food aid was much higher for the remote villages.

No household-specific data exist on distribution of relief food within villages. Recall-based information indicates sizable intravillage variations, although families were supposed to share equally. Part of the problem can be ascribed to the design of the food-aid policy. The food ration per family was based on two key assumptions—equal weight for every member in terms of food requirement and a maximum family size of six members. The ration per family thus had an inherent bias against large families, particularly those with a high proportion of adult members. Furthermore, the application of universal eligibility (except the nonresidents) fails to recognize food aid as one of several coping instruments. Families are unequal in terms of their coping capacity.

It is probably valid to argue that the relief policy was less favorable to the poor. The original plan to extend relief only to those who had no resources failed for lack of sufficient information and political sensitivity. The residence requirement for eligibility must have significantly excluded the poor from the distribution. Most of those who migrated earlier were probably among the poor. The two-tier distribution modality (free distribution and cash payment at a subsidized price) was also unfavorable to the poor. In the absence of a program to augment their income, the poor could not effectively participate in the monetization scheme.

Building Coping Capacity: Selected Project Experiences

The year 1985 witnessed a large-scale famine relief operation in western Sudan. By 1986, the regional government of Kordofan had developed a rehabilitation strategy based on the concept of a zonal framework (KRMFEP 1986). The region was divided into three zones (northern, transitional, and southern), then subdivided into six zones. The zones were designed to show low intrazone but high interzone variability in their ecological features, potential agricultural base, and population settlement.

The plan identified strategies applicable to all as well as to specific zones. The primary goals were to restore the degraded natural environment through rehabilitation of forest and natural pasture, to improve availability and distribution of rural water supply, to promote agricultural production and income, and to provide support for households targeted for resettlement or reconstitution of their asset base. The relative emphasis of these goals varied across zones.

A sample of ongoing rehabilitation projects in the region is shown in Table 68. They show considerable comparability to the priorities set for the region. The projects cover rehabilitation of land and water (such as restocking of gum arabic

Table 68—Sample of ongoing rehabilitation activities in Northern Kordofan, 1988/89

Intervention Program	Source/Sponsor[a]	Target District	Target Group
Smallholder credit for cash-crop production	ABS/USAID ABS/Sudan ABS/SCF ABS/IFAD CARE/Netherlands	El Obeid Um Ruwaba Um Ruwaba En Nahud En Nahud	Villages selected on the basis of high production potental; membership open to farmers with access to land and proven repayment capacity
Restocking of gum arabic trees and other forestry[b]	UNSO/WFP/UNDP	Um Ruwaba El Obeid Bara	Villages with low acacia sengal tree coverage are selected. Open to farm families who own land, work on farm, and reside in the villages
Restocking of small animals (mainly goats)	UNICEF[c]	Bara El Obeid	Low-income women with no livestock
	OXFAM	Sodari	Nomadic families with no more than five goats or sheep
Home garden development	UNICEF	El Obeid	Low-income women
Irrigated agriculture	UNICEF	Bara	Low-income women
Grain storage (village level)	UNICEF	El Obeid Bara	Low-income women
Cheesemaking	UNICEF	El Obeid	Low-income nomadic women

[a]ABS = Agricultural Bank of Sudan; USAID = United States Agency for International Development; SCF = Save the Children Federation; IFAD = International Fund for Agricultural Development; UNSO = United Nations Sudano-Sahelian Office; WFP = World Food Programme; UNDP = United Nations Development Programme; UNICEF = United Nations Children's Fund; OXFAM = Oxford Committee for Famine Relief.

[b]CARE/Canada in En Nahud district, SCF/US in Um Ruwaba, UNICEF in Bara and El Obeid, and ILO (International Labor Organization) in Bara operate small-scale forestry projects.

[c]UNICEF also undertakes other projects such as poultry, mechanized farming, composting, seeds, beekeeping, handicrafts, adult education, and village water supplies throughout Kordofan Region.

trees), asset reconstitution (such as restocking of goats), and promotion of agricultural production (for example, through provision of production credit).

These microprojects are not expected to reverse the process that has rendered the rural economy vulnerable to a recurrence of famine. But they are likely to facilitate and contribute to the establishment and protection of the coping capacity of the famine-prone population. Selected cases of such intervention programs are examined here to learn from their experiences and to draw lessons that should be incorporated in devising a strategy for famine prevention in the drought-prone areas. The case of the Jebel Marra Rural Development Project in Darfur is added to the review of Kordofan-based projects. It highlights the importance of technological change in agriculture as a source of growth and an income buffer in time of crisis.

Food-for-Work Planting: The Gum Belt Project

The gum belt of Kordofan stretches from west to east within the Sahelian zone and contributes nearly 50 percent of the world's production of gum arabic. Typically, farmers in the gum belt maintain gum gardens as part of their traditional agroforestry practices. The gum trees, acacia senegal (*hashab*) in particular, play a central role in maintaining the agro-ecological balance in the otherwise delicate and fragile ecological zone. In addition, the trees provide direct income to the farm population.

Gum production steadily declined in the 1980s, reaching its lowest point in 1984 (Table 69). A continuous aridity in the 1970s and 1980s, unfavorable official producer prices, and the frequent dependence of the rural population on income from tree products (charcoal and firewood) as a fallback in times of crop failure contributed to a combined outcome of decline in tree density and productivity. There is now marked evidence that the gum belt is shrinking, at least on its northern frontier.

The areas that require the greatest tree coverage are the most exposed to desertification. Such recognition has prompted various levels of response for rehabilitating the gum belt, especially since the 1984 drought. A joint United Nations Development Program and Government of Sudan project began in 1981 to rehabilitate the Kordofan gum belt. The primary goal of the project is to halt degeneration of the environment, but it has secondary goals of creating additional employment and improving the income position of participating farmers.

Table 69—Index of gum arabic production, 1974-87

Period	Production	Index
	(1,000 metric tons)	
1974-78	39.3	100
1980-81	34.0	87
1982-83	32.8	83
1984	14.1	36
1985-87	25.2	64

Source: Based on data from the Gum Arabic Company, Khartoum.

The framework for implementation of the Gum Arabic Restocking Project is based on central nurseries that serve satellite villages in their designated areas. Nurseries are selected on the basis of proximity to a permanent water source, road accessibility, and density of settlement. Each nursery serves a selected number of villages. Farm households are selected from participating villages. Village committees serve as the entry point for participating farmers.

The central nurseries produce and multiply seedlings, and the project delivers the seedlings. In addition, it sells water at a subsidized rate to water-deficit villages and delivers food rations. By mid-1989, the project had covered about 12,000 farmers in nearly 300 villages (Table 70). In the first three years, the project covered on average 27 villages per year at a rate of 29 farmers per village. There was a jump in the rate of coverage in 1984 and 1985, mainly in the average number of villages. Since 1985 there has been an increasing demand for expansion of enrollment. The integration of food aid into the project package, the realization of improved prospects for better gum prices, and increasing awareness of the project's desire to revitalize the environment are presumed to contribute to this surge in demand. The project management has shown some flexibility in its rules, at least in raising the quantitative quota per village since 1986. But, because of resource limits, the management exercises administrative rationing to restrict enrollment.

Project reports indicate that effective tree coverage due to the project averages 141 trees per feddan (338 trees per hectare). This amounts to about 57 percent of the recommended planting rate. Findings in IFPRI survey villages concur with the observed rate of low survival. On average, the low-density villages in Table 71 in fact show a much lower survival rate. In addition, data from El Obeid and Bara villages show emerging patterns. First, there are considerable variations in gum output per farm across villages due to variability in tree density, age specificity of tree productivity, and fractions of trees tapped and harvested. Second, project fields have a relatively high tree density compared with traditional *hashab* fields. Third, the short-term employment effect of the project appears to be modest. Fourth, the food ration is the only source of variation between the income sources of participants and nonparticipants. A low income share from gum production is largely

Table 70—Trends in gum belt project participation, 1981-88

Year of Initial Participation	Number of Villages	Number of Farmers	Number of Farmers per Village	Seedlings Produced
		(new participants)		(thousands)
1981	25	673	27	990
1982	27	756	28	1,100
1983	29	915	32	1,240
1984	39	1,479	38	1,840
1985	46	1,651	36	2,375
1986	37	2,107	57	2,849
1987	39	2,172	56	3,090
1988	30	1,765	59	3,320

Source: Based on data from the Department of Forestry, El Obeid.

Table 71—Density, farm size, and yield for low- and high-density farms in gum belt villages, 1989

Item	Gum Belt Project Farms: Low-Density Villages	Gum Belt Project Farms: High-Density Villages	Traditional Hashab Garden (Genena)
Trees/hectare	173	332	110-140
Farm size (hectares)	2.9	3.2	4.4
Yield (kilograms/tree)	0.34[a]	1.04[a]	1.04-1.59-1.13[b]
Fraction of gum-producing trees/year[c]	0.13	0.30	n.a.

Source: International Food Policy Research Institute survey, 1989.
Note: n.a. means not available.
[a]Mean yield of a young tree under the project.
[b]Yield varies by age of tree; it is low in early years (6-8), peaks in middle age (9-12), and drops in later years (13-18). No consensus has been established as to whether the yield in old age is higher or lower than when young, even though most tend to suggest the older trees yield better.
[c]On average, 50-60 percent of trees are tapped every year.

expected, given that the trees take six to eight years to mature and most of the villages were not ready to tap in 1988. The benefits of the project are of course larger in the long run as trees move into their peak productive age cycle and other crops benefit from improved soil fertility and moisture.

At the project level, the management should adhere to the primary goal of pursuing a wide coverage of area through promotion of a minimum recommended planting rate. In the short run, given the scale of the project, one option for broadening the scope of participation is to modify the modality of the project operation. It can, for example, focus on a "model farmer" approach, where groups are formed around model farmers, seedlings are provided to groups on a rotating "credit" basis, and the actual allocation is conditional on the groups' performance. In addition, it is necessary to modify the current incentive structure to allow linkage of payments to task measures of output. Food must be linked to the task rate and limited to the preproduction phase.

Improved Agricultural Technology

Compared with the rest of Darfur, Jebel Marra and its surroundings represent an area of high agricultural potential. The area benefits from a long-term rural development project that has a component of agricultural-technology promotion. The extension of this technology has enhanced the production as well as the employment-absorption capacity of the Jebel Marra area in recent years.[8]

[8]This section draws on the work of Graciela Wiegand-Jahn (1989). The research was a cooperative effort between IFPRI and the Jebel Marra Rural Development Project. All results presented in this section are derived from data sets provided by the Monitoring and Evaluation Department of the project.

In the early 1980s, the area experienced lower than usual rainfall. In 1984, as in much of western Sudan, the lack of rain was severe. The area had to cope not only with food shortages for its own population but also had to absorb a large number of refugees who came from areas that were even more affected (other parts of Darfur and Chad).

The drought of 1984, which led to a total crop failure in many parts of Northern Darfur, led to reduced production in the Jebel Marra project area. All villages in the project area experienced a drop in grain production, but villages that had access to modern inputs through extension services experienced smaller declines (Table 72). Within the participating villages, households with access to improved inputs and extension services achieved a higher grain output per capita and managed to produce enough to meet calorie needs.

A comparison of the participating and nonparticipating households shows that only a few households in the participating group had no male head in the drought year, while 50 percent of the nonparticipating households had to manage the drought year without a male head of household (Table 73). The relatively small fluctuation in household size and in percentage of female-headed households in the participating group over the years suggests that these households were in a much more stable position during the crisis year of 1984/85 than the nonparticipating households. Those without access to modern inputs produced less and had to manage by adjusting household size through out-migration of adult males. Coping was much easier for those participating in the project.

Typically, farmers from Northern Darfur come to the project area during the harvest period in search of employment. In 1984, a large number of refugees came to the area from places that were severely affected by the drought (Northern Darfur

Table 72—Grain production before, during, and after the 1984 drought, by participation in the Jebel Marra Project

	Grain Production per Household			
			Participating Villages	
Season (wet)	Participating Villages	Nonparticipating Villages	Participating Households	Nonparticipating Households
	(kilograms)			
1982/83	980[a]	520[a]	1,148[a]	779[a]
1983/84	973[a]	449[a]	1,361[a]	785[a]
1984/85	624[a,b,c]	220[a,b,c]	867[a,c]	544[a,c]
1985/86	1,844[a]	1,568[a]	2,082	1,745
1986/87	1,064	1,173	1,498	1,099

Source: Computed on the basis of Jebel Marra survey data.
Note: The village of Taij was excluded because of unusually high yields.
[a]The mean of the participating and nonparticipating groups was significantly different (t-test).
[b]The mean was statistically lower than in previous years (t-test).
[c]Per capita grain production in the 1984/85 season was 178 kilograms for participants and 75 kilograms for nonparticipants. There was no significant difference within participating villages. The same pattern appears when the comparisons are made on the basis of proportion of households with less than 1,000 calories per capita per day. The percentage was higher in nonparticipating villages (79) as compared with participating villages (41).

Table 73—Household size and percentage of female heads of household in extension villages of the Jebel Marra area

Survey Period	Participating Households: Household Size	Participating Households: Female-Headed Households	Nonparticipating Households: Household Size	Nonparticipating Households: Female-Headed Households
	(persons)	(percent)	(persons)	(percent)
Wet season, 1984/85	5.01	9	3.31	47
Postharvest, 1985	...	16	...	50
Postharvest, 1988	6.65	11	5.78	23

Source: Computed on the basis of Jebel Marra farm survey data.

and Chad). Most came to the project area in October and November 1984, around harvest time. Many settled around existing villages in the project area, in the fertile lower-valley zone that experienced a significantly better grain harvest than other zones in the drought year (see Table 74).

Improved agricultural technology was thus a powerful tool for mitigating the drought crisis. Given the mobility of labor in the region, a concentration of technological change in the comparatively high-potential area provided respite for drought refugees from a large surrounding area.

Credit for Production and Consumption

The Agricultural Bank of Sudan (ABS) initiated a cooperative-based credit program in El Obeid district in 1981/82 for production enhancement and consumption stabilization. The program caters primarily to the credit needs of small farmers in rainfed agriculture. ABS provides targeted loans to finance current production and storage.

Table 74—Distribution of refugees in Jebel Marra area, Darfur, by agro-ecological zone, 1984/85-1985/86

Zone	Village Population	Number of Refugees, 1984/85	Number of Refugees, 1985/86
Mountain	1,463	157	52
		(11)	(4)
Upper valley	1,216	209	87
		(17)	(7)
Lower valley	1,542	706	303
		(46)	(20)

Source: Computed on the basis of Jebel Marra farm survey data.
Note: The numbers in parentheses represent the number of refugees in percentage of village population.

Village-based cooperatives that have a legal entity serve as a channel for delivery of credit and marketing services to small farmers. Each village can form one cooperative, provided that it has a minimum of 50 members. Membership is open to resident farmers who are over 18 years of age, and who have access to land and a sound credit record.

Each borrower is allowed to finance a fixed maximum area per crop. ABS determines the loan rate per area. The total loan per borrower is a function of the loan rate per area and the total area approved for financing. Production loans are disbursed in three installments. This strategy is intended to ensure that the loan is used for designated operations and to minimize the risk of loan default. ABS charges an administrative fee on its loaned funds.

ABS has so far reached a maximum of 21 cooperatives covering nearly 2,000 members per season (Table 75). A significant number of cooperatives were registered in the 1983/84 and 1984/85 seasons, the two drought years, but only a small fraction of them were financed. Despite an increase in demand for loans, ABS was unwilling to risk a high loan default rate. This is evident in the drop in the loan rate per area.

Available evidence of loan utilization shows that a large percentage of ABS loans are used for food consumption. Studies by the Kordofan Rainfed Agricultural Project and ABS (Technoserve/ABS/USAID 1987; Bielen, Crauder, and Rivarola 1989) show that 68 and 83 percent of the loans were used for food consumption in the 1986/87 and 1988/89 seasons, respectively. The IFPRI study shows an average of 73 percent for the 1988/89 season. No more than 20 percent is used for the purchase of current agricultural inputs and the cost of labor. Food is thus a top priority of ABS clients.

Loans are seldom recovered in full on the first due date (Table 75). Exceptions to this are 1988/89 and the early years. ABS was effective in its early years when loan size was small; however, high rates of current loan default occurred in the drought years from 1982/83 to 1984/85. The lowest on record was 1984/85, the peak drought year.

ABS's strict application of debt collection policy (no debt relief, no rescheduling of debts, and no new loans without a settlement of old loans) contributed to a recovery of its past loans in 1986/87 but drove out a large proportion of borrowers. Farmers express their reluctance to join ABS for fear of loss of income and assets in case of crop failure.

The weak performance of ABS in terms of its record of low profitability and an apparent decline in loan participation has raised serious doubts about its narrowly focused goal of financing agricultural production in such a highly volatile environment. There are serious questions to be dealt with. Should ABS broaden its mandate to contribute to improvement of the underlying conditions that cause production instability? Should ABS attach greater weight to farmers' expressed desire for income or investment diversification? Could ABS be used as a source of alternative financing in times of severe income failure in rural areas? ABS may not be particularly positioned to respond to these needs, but these are relevant points to be addressed in the context of drought-prone areas like Northern Kordofan.

Restocking of Livestock

The UNICEF goat-restocking project represents an asset-rehabilitation effort in a postfamine period. The project, which started in late 1986, caters to poor

Table 75—Cooperative credit program in El Obeid district, Kordofan: loan participation and performance, 1980/81-1988/89

Season	Cooperatives Financed	Cooperatives Financed as Percentage of Registered Cooperatives	Percentage of Members Financed	Area Financed per Borrower	Average Loan per		Recovery Rate at First Due Date
					Area	Borrower	
				(mkh)[a]	(SD£)		(percent)
1980/81	3	100	101	5.84	17.26	100.84	50
1981/82	11	100	94	6.44	29.73	191.46	62
1982/83	12	75	69	9.01	23.94	215.70	6
1983/84	20	77	71	8.96	25.04	224.36	12
1984/85	18	53	51	8.48	20.27	171.89	2
1986/87	11	32	22	7.31	33.11	242.03	19
1987/88	19	49	42	8.79	38.99	342.24	38
1988/89	21	54	41	9.66	66.04	637.98	82

Source: Based on data provided by the Statistics Unit of the Agricultural Bank of Sudan.

Note: The Agricultural Bank of Sudan extended credit mainly in the form of seeds in the 1985/86 season. This was not typical of any of the other years, when there was a nine-to-one ratio of cash to commodity package.

[a]One mkh (*mukhammas*) = 0.73 hectare.

female-headed households in the drier areas of Northern Kordofan, particularly in El Obeid (Um Esheria) and Bara districts. It was felt that income controlled by women had the greatest and most effective impact on child nutrition and health, and children of these households had become the most vulnerable in the postfamine period.

The project provides two breeding female goats to qualified participants. Eligibility for participation is conditional on proof of income and wealth status and written consent to abide by the rules of participation. Such rules include, among others, agreement to use goat products to feed the participant's children, to pay back two female offspring within a 24-month period, and to refrain from selling female goats to ensure growth of stock.

By the end of 1989, a total of 1,521 breeding female goats were distributed to 760 female-headed households, and another 248 goats were distributed to 124 participants from the collection of offspring from the original parent stock. By the end of 1989 the project had benefited 398 families in 10 villages in Bara district and 486 families in 11 villages in El Obeid (Um Esheria) district.

The IFPRI survey results indicate that participation in the project has apparent positive economic effects. Although ownership of livestock is generally low, families in the project appear to have more livestock. Ownership of goats has also contributed to improvement in income position. In addition, it has improved the relative income position of the participants. Twenty-seven percent of the project group belonged to the relatively high income position, compared with 10 percent of the control group. Such improvements in asset and income position have translated into higher levels of calorie consumption.

The project is under pressure to expand to meet a growing demand for participation. Given UNICEF's limited capital budget for the project, its future growth and sustenance depend on how fast it can promote expansion through progeny distribution. Crucial to such expansion is the performance of growth indicators, especially birth and death rates. The survey shows that there are sizable variations in these growth indicators across villages. The project lacks effective veterinary-service support to reach the participants. In addition, there are variations in the degree of monitoring and supervision of growth performance. Where such monitoring is lax, there is a tendency to underreport births, especially in the case of female offspring, in order to delay repayment. It is thus crucial that growth performance, monitoring, and supervision improve.

8

POLICY CONCLUSIONS

Drought-famine relationships are complex. Therefore, policy recommendations to deal with them are also complex and closely interlinked. Nevertheless, an attempt is made here to tie together the major policy conclusions of this study and to do so with a sense of priority for famine prevention.[9]

General Policy Priorities

Political Stability

The peaceful settlement of the conflict in the South is the most important element for the economic well-being of the whole country and for the most vulnerable groups in particular. Not only does the cost of war to human life continue to be high, but it has also led to the displacement of millions of rural people, rendering them unproductive and making them prime clients of food relief. Furthermore, large areas in the savannah belt with adequate rainfall and high productivity, especially for foodgrains, are becoming increasingly inaccessible because of the war. This is a lost opportunity for the country to increase its total grain production and employment for the rural population and hence to reduce its vulnerability to food insecurity.

Participation of Rural Population

Insofar as policies affect rural areas directly, the stabilization of these areas in prevailing situations of discontinuity requires the active participation of the rural population. This participation should be a two-way process: on the one hand, decentralization of power from the center to local, provincial, and regional levels is called for, and on the other hand, rural people should form their own rural institutions that would identify their problems, propose solutions to these problems, and commit resources toward meeting the costs involved. Adoption of such policies would probably enhance stability even when the central government changes. Thus the rural people would have their interests safeguarded despite the volatility of the political system.

Stable rural institutions are of critical importance during food shortages and famine crises. If local relief and rehabilitation committees were already in existence, they could be mobilized quickly and would be of great assistance to the

[9]The set of conclusions presented here also builds on insights gained from a policy workshop in Sudan, where the study findings were reviewed by leading policy analysts and policymakers. The workshop's findings are synthesized in Zaki, von Braun, and Teklu 1991.

national institutions and foreign or domestic relief agencies in supplying information, identifying the needy, and distributing food.

Macroeconomic Policies

Macroeconomic policies should be geared toward establishing a sound environment where fiscal, monetary, trade, and exchange policies provide a framework for reducing drought-hunger relationships. Policies should be comprehensive and effective in dealing with structural problems and economic distortions in favor of efficient resource allocation and sustained economic growth. Control of inflation is crucial to economic and political stability.[10]

Specific Policy Priorities

Sustainable Growth in Traditional Rainfed Agriculture

The call for a broad-based strategy for development of rainfed agriculture, which was initiated in a government study (Sudan, Ministry of Finance and Economic Planning 1986), is central to a comprehensive famine-prevention strategy.

The government study defines the goals of rainfed agriculture: to promote production to meet regional self-sufficiency and national self-reliance; to enhance sustainable income and employment generation; and to conserve, rehabilitate, and improve natural resources. Justifications for the pursuit of regional self-sufficiency (particularly millet in the west) are based on recognition of current low levels of infrastructure and market connections. The study recognizes constraints imposed by low and variable unimodal rainfall, seasonal labor shortages, the shrinking productive land base and declining soil productivity, and existing low-input farm technology and managerial practices.

The present trends in traditional rainfed agriculture, with farmers resorting to more subsistence farming, need to be reversed. The rural economy needs to move toward monetization by improving farmgate prices of all crops, whether foodgrains or cash crops, by opening up produce and input markets, and by improving rural financial markets.

Rural Infrastructure

Available evidence reveals a low level of infrastructural development in Sudan, especially in the west. Infrastructure development is a critical component in the promotion of a stable and sustainable rainfed agriculture. Reduction in the cost of transportation provides improved opportunity for mobility of goods and people. It facilitates expansion of market outlets, enhances market integration, and reduces the probability of market failure. Expansion of the transport network also facilitates improved access to social overhead services (such as health, education, potable water), which contributes to improved productivity and, consequently, to increased income-generation capacity and improved nutritional status. Experience from other countries also indicates the positive linkage effect of infrastructure development on

[10]A comprehensive discussion of these issues and their links to famine is presented in Atabani 1991 and is therefore not expanded here.

expansion of rural services and diversification of the rural economy (IFPRI 1988). Thus, expansion of infrastructure has potentially great short- and long-term benefits to Sudan.

Public Works Programs

The provision of road infrastructure (in addition to water supply, reforestation, and so forth) should occupy a central place in public works schemes. It must be positioned where it has a great impact on providing a critical and catalytic link in the development process. Under present cost constraints, this may mean giving priority to areas of high agricultural potential. To promote employment and a steady flow of income, the emphasis should be on labor-intensive techniques that are tailored to the employment needs of the rural population. Such synchronization of provision of work with the employment needs of those who seek employment (wage rates presumably are set to attract the most needy) has the added advantage of creating incentives to shift away from current employment practices with adverse environmental effects (for example, cutting trees to make firewood and charcoal). Such a practice of providing employment to the food-insecure to create infrastructural assets could also be expanded in times of crisis to generate relief employment to protect income and asset bases.

The main cost component in such infrastructure and employment-generating schemes is payment for labor. Since the majority of the participants would come from low-income families, they are expected to spend a large share of income on food. Food payments as wage components can play a role, since, given the current development of market infrastructure, market transaction costs to obtain food at the marketplace are high. Food wages provide a more effective utilization of food aid for development undertakings. This observation is derived from Sudan's experience in the 1980s, when, despite much-expanded food aid, little was used for development projects.

Government policies need to be directed toward the eradication of absolute rural poverty, which is the root cause of food insecurity. In addition to the economic policies outlined above, special attention to areas frequently visited by drought is required. Special employment and rural works programs that would enhance rural incomes, reduce vulnerability to food shortages, improve the efficiency of relief and rescue operations in case of need, and reduce environmental hazards should be given top priority. Sudan already has some experience in such programs, such as the International Labor Organization's labor-intensive project in White Nile Province, where a rural work program helped with construction of rural feeder roads, water supply, afforestation, and the like, and the Gum Arabic Restocking Project, with headquarters in El Obeid, that exchanges food and basic necessities for the commitment of rural people's land to be restocked with gum arabic and worked with their family labor. In all of these efforts, replicability should be an essential feature and measure of success.

Supply of Inputs

Traditional farming is spread over a vast area and in some cases may be located hundreds of kilometers from input markets. The government may have to ensure adequate and timely availability of these inputs at prices that farmers can afford. Farm-input prices need not be heavily subsidized, but policy can affect prices by reducing transaction costs. But because of the vast farming area, the government capability may be neither adequate nor most efficient in making these inputs readily available; hence, there is room for the private sector to undertake a significant role in the acquisition and distribution of farm inputs. In case the private sector takes an active role in the farm-input trade, one of the measures that the government can undertake to reduce transaction costs is the supplying of credit to the farmers for input purchases.

Adaptive Research, Technological Packages, and Extension

There is an urgent need to bolster adaptive research efforts and to develop, adopt, and continuously disseminate technologies based on existing knowledge and practices that would enhance productivity, increase incomes, augment limited inputs (land and water in particular), reduce production variability due to low and variable rainfall patterns, promote conservation of soil fertility, and curb environmental degradation.

The emphasis should be on technological change to assist in reversing the process of declining agricultural productivity. In the context of Sudan's low-resource and drought-prone areas, such a role entails the generation of technological capacity to deal with low and variable rainfall, low soil fertility, seasonal shortages of labor, and farmers' management practices. The bases of such a process lie in improving the agronomic environment with existing technologies. Such technologies involve improvement in the structure, fertility, and water-holding capacity of existing poor soils, particularly sandy soils in the arid regions, and increased availability of water. However, technologies that focus on the existing knowledge base of resource conservation have a limited capacity to achieve rapid agricultural growth (Staatz 1986). It is imperative to move to high-input technology that uses greater proportions of purchased inputs and fits into both the arid tropical environment and farmers' production-income-consumption strategies. But available on-shelf technologies that are adapted or developed for the African environment are limited at present (Matlon and Spenser 1984; Stoop et al. 1982). The strategy should, therefore, realize the great challenge ahead and call for promotion of research and development to ensure a sustained and viable development process.

The Jebel Marra experience in Darfur in 1984-85 also establishes a strong case for increased access to agricultural technology, at least in high potential areas as a start. Families with access to irrigation and improved production technology, such as improved plows, have demonstrated a greater capacity to buffer periodic food crises. This capacity has been enhanced through improvement in their level of food production, income, and asset base. Moreover, in time of crisis, these areas have greater capacities to transfer food or to provide employment for temporarily distressed migrants.

In the area of water conservation, attempts should be made to improve dry-farming techniques and to introduce contour cultivation and drip irrigation. Water-harvesting techniques, such as small dams in watershed areas like Jebel Marra and heavy plowing of hard-crust *Nagaa* soils (caused by deposition of silt in water-course deltas), seem ready for wider application. Recently, some serious steps were undertaken to expand tubewell irrigation in Northern Kordofan basins that has provided opportunities for perennial production of high-value crops like citrus and vegetables, increasing incomes from agriculture and expanding employment.

The development of technological packages in research centers is necessary but not sufficient. Sufficiency would be partially met by the provision of efficient agricultural extension services that would deliver these packages to the farmers in good time and in acceptable forms. Such services are yet to be developed for Sudanese agriculture or, in particular, for the traditional rainfed subsector. Apart from the extension services provided by the Jebel Marra Rural Development Project, there is hardly any extension service in operation in the traditional areas. After the establishment of the adaptive research facility in western Sudan, serious efforts should be undertaken toward development of extension services that would disseminate the technology packages to farmers.

Protection of the Environment in Drought-Prone Areas

Preserving, promoting, and protecting the environment is fundamental to enhancing the future productive capacity of the drought-prone areas. Creeping desertification and climatic change, increasing human and livestock population, impoverishment of the rural population, and past policy failures (most notably the rapid expansion of large-scale mechanization into marginal and fragile areas, and the choice of spatial distribution of water points in the arid and semi-arid zones) have contributed to the degradation of the environment. It is essential that a strategy for protecting the environment should call for policies that would modify the existing common property rights system, provide incentives for voluntary resettlement of the rural population, and align farmers' time preferences with society's preferences by providing income support in times of stress. The latter measure is imperative for slowing down rapid deforestation and encouraging the rural population to participate in protecting the environment.

Emergency Preparedness and Relief

The basic concept of famine preparedness entails a public commitment to intervene effectively in time; to build institutional capacity at national, regional, and local levels; to detect and diagnose indicators of distress; to prepare programs and projects on a continuous basis; and to execute development and relief undertakings in times of revealed needs. Such actions will increase the preparedness of Sudan to meet emergency situations of localized or nationwide food shortages and famines.

Buffer Stocks for Price Stabilization

Central to these actions is the development and efficient operation of a buffer stock that would be located at storage facilities close to high-risk areas. The stocking and the dissemination of grains require clear guidelines as to the eligible groups, the period at which distribution commences, the price of grains for each category within the eligible group, and the payment mode, whether in cash or in kind, of public works.

No comprehensive data exist on the extent of stock-building in Sudan, particularly in the private sector. The public stockholding policy was initiated in the mid-1960s with the authorization of the Agricultural Bank of Sudan (ABS) to maintain cereal buffer stocks, to stabilize support prices, and to make grain available in times of food shortage. The annual average size of ABS stock never exceeded 10 percent of total cereal production in any season until 1984/85, owing to financial and storage constraints (Abdel Nour 1988). The delayed and limited role of the government in providing relief food in 1984/85 was related to the lack of both adequate food reserves and capacity to import. ABS stockpiling, however, was greatly expanded in the aftermath of the 1984-85 famine. Issues that are likely to loom in the future are determination of "optimum size," procurement and release prices, and the extent of involvement in foreign trade for price stabilization.

Relief-Management and Early-Warning Systems

Relief management entails establishment by the government of a high-powered system with a network extending to local, provincial, regional, and national levels. The objective of such a relief system should be not only the supply and distribution of food during shortages and famines, but also the prevention of famine in the first place. Thus the relief institutions should establish a well-equipped (both in terms of equipment and professional personnel who are highly motivated) early-warning system with strong links to local governments and communities.

Strengthening Rural Health and Sanitation

A strong rural health system is a necessity under any circumstances and not just from a famine-prevention perspective. The strong linkages between infrastructure and health and sanitation in rural areas have been highlighted in this research. The strengthening of rural health services is a key function of public investment for human resource development. Not only does improved hygiene directly affect child nutrition, it facilitates coping with drought-related consumption fluctuations. A strengthened health-service system can be a powerful tool for managing relief more effectively. Therefore, the quality of health services and the density of the network in rural areas need to improve. Community participation and resources should not be underestimated in molding an effective rural health system. The rural poor appreciate the role of health services for survival and are willing to commit resources. An effective, active system deals with the symptoms of chronic food insecurity and thereby strengthens the capacity of the poor to survive transitory food insecurity and the related health risks.

Legislation for Famine Prevention

For the relief institutions to operate efficiently, there is a need, first, to design a well-structured relief legislation that would incorporate the basic relief policies to which the government is fully committed. Second, in addition to promotion of production and infrastructure bases, public policies should be concerned with bridging any shortfalls in domestic production to meet food demands. Third, dependence on food aid should be minimized, since factors other than humanitarian considerations (such as world market situation and political leverage) play important roles in its allocation. Hence, it is necessary to maintain adequate buffer stocks or enhance the capacity to import or both. In the case of Sudan, policies of stockholding and foreign trade have become more important because of increased production shortfalls. Fourth, in the short term, relief policies should include special programs for the most vulnerable segments of the population. Feeding programs for children, infants, and their mothers to dissipate hunger and malnutrition, and medical assistance to reduce the incidence of diarrhea and other epidemics, would strengthen these weak groups and improve their chances of survival in the face of food shortages.

The relief legislation should detail the responsibilities of the national and regional governments and the local authorities in identifying and declaring areas of food shortages and famines and dissipating the impacts of these shortages and famines. Each vulnerable locality should be obliged to maintain a certain amount of grain in storage in accordance with a timetable drawn up on the basis of monthly requirements, with a declining balance as the agricultural production season advances and a buildup in the same manner. The authorities at the local level would be required to prepare periodically (weekly and monthly) a report that would include detailed statistics and information on production, stocks, withdrawals, and the number of people likely to be subject to malnutrition or starvation. The early-warning system would, in addition to other information on rains and the like, compile these data at the provincial and regional levels, analyze them, and present a full report to the regional and central authorities with recommendations for specific actions authorized by the legislation. The central authorities would make public announcements about the situation and seek assistance, if necessary, from the international community. Authorities, especially at the local level, would then be entrusted with the field inspection of the relief work and assessment of the effectiveness of the relief program.

Linkages between Relief and Rehabilitation

Relief and rehabilitation are integral to the development process. In the context of drought-prone areas, where income levels are low and variable and famines are recurrent, it is imperative to devise a strategy for protecting the development process from going off track. Rehabilitation should be integrated into such a process to ensure that no time is lost in getting back to the development process. Sustenance of life in periods of emergency, and interventions to rehabilitate environmental, community, and household assets and to enhance and protect household incomes fall in the realm of development process. The critical link between relief/rehabilitation and development lies in the choice of programs and projects toward these ends. Information on the relative impact of these programs and projects on sustained growth in food supply, employment and income, on moderation of variation in production and income, and on protection of assets is vital for selection of the optimal policy mix. This information represents an important area that future research work should focus on in order to provide an empirical base to assist policymakers in choosing efficient and effective projects that are optimal for an integrated relief-rehabilitation-development framework.

APPENDIX

The Relief and Rehabilitation Commission

The responses to the 1984-85 famine represent a great deal of regression from the concepts and procedures embodied in the 1920 famine regulations. The key omissions were a public policy initiative to detect and respond to famines, establishment of administrative institutions, and the linkage of relief to development. The de-linking of relief from development has been, in fact, a typical feature of the whole development approach since independence. The future lies in combining these components and developing a flexible and efficient system of response to a famine threat. The establishment of the Relief and Rehabilitation Commission (RRC) represents a step in the right direction.

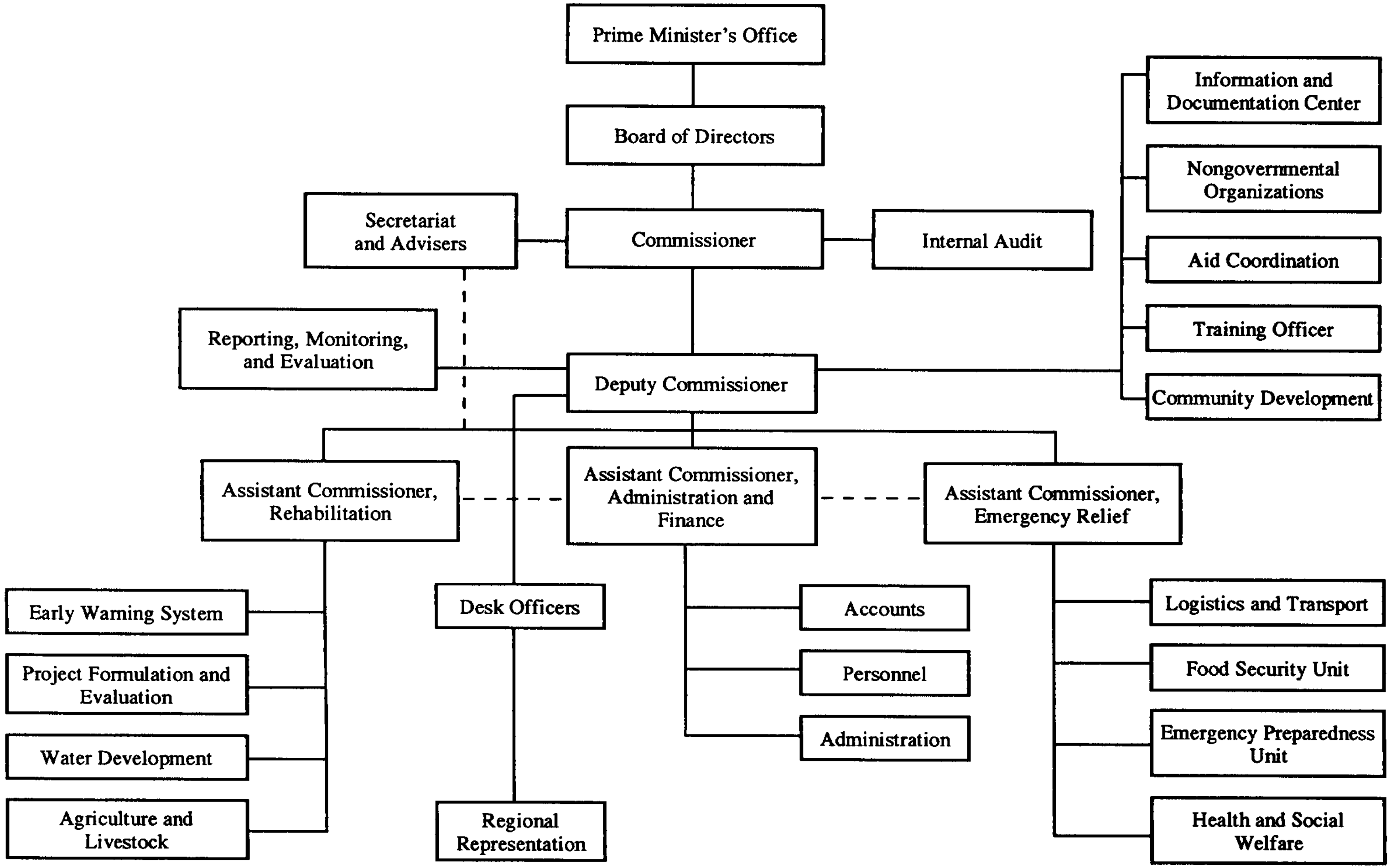
This commission was established in May 1985. It is an independent corporation directly under the prime minister, with a board of directors and a ministerial commissioner (Figure 15). Article 4 of the RRC Act states that "the objectives of the Commission are to draw and implement policies, plans, and programs for mitigating the effects of and rehabilitating areas affected by catastrophes, drought, desertification, and degraded environmental orders, and to mobilize the necessary international and local resources." The duties of the RRC are carried out in close coordination and cooperation with the Ministry of Finance and Economic Planning, which is the central government authority responsible for the country's socio-economic development planning and budgeting.

The early-warning surveillance unit has been incorporated in the RRC since March 1986. There are some similar units already operating in some of the technical ministries and autonomous organizations, such as the Ministry of Agriculture and Natural Resources, Ministry of Health and Social Welfare, and the Meteorology Department in the Ministry of Defense. The early-warning unit of the RRC does not collect data and, therefore, does not duplicate the data-gathering activities of the technical ministries. It uses the data collected by these ministries to yield indications about the approach of problematic situations.

The government Act relating to regulations for the work of NGOs in the country was passed by the constitutional assembly only in early 1988. The Ministry of Health and Social Welfare was authorized to register the NGOs. However, the RRC still plays an important role in the coordination and technical supervision of their work in the Sudan. This role requires a special unit in the RRC to monitor and supervise the NGOs involved in relief and rehabilitation. This unit keeps appropriate records on the credit potentials of the organizations and their sources of funding.

The authority of the RRC Commissioner is delegated to the governor of each region. At the same time, all governors are members of the board of directors of the RRC. Each region has a regional relief committee headed by the governor, who may delegate this authority to one of his or her senior officials. In this manner, the connection between the RRC and all regions of the country is realized.

Figure 15—Structure of the Relief and Rehabilitation Commission in 1988



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Tesfaye Teklu is a research fellow at IFPRI, Joachim von Braun is the director of IFPRI's Food Consumption and Nutrition Division, and Elsayed Zaki, a former Minister of Finance and Economic Planning of the Republic of Sudan, is a private consultant.

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